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Thesis

ECONOMIC EVALUATION OF ADOLESCENT REPRODUCTIVE HEALTH EDUCATION INTERVENTIONS IN CHILINH, VIETNAM

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ECONOMIC EVALUATION OF ADOLESCENT REPRODUCTIVE HEALTH EDUCATION INTERVENTIONS IN CHILINH, VIETNAM

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Key words

Health economics, economic evaluation, cost-effectiveness, cost-utility analysis, Markov model, decision-making, reproductive health education intervention, reproductive health problems, adolescents, Vietnam

Abstract

Background

Adolescents and youths in Vietnam aged between 10 and 19 make up 19% of the country's population. The ability of young people to contribute to a nation's productivity and prosperity is dependent on how well they can avoid health risks and chronic diseases, including those associated with sexual and reproductive health. Reproductive health care and prevention programs for adolescents and youths are prioritised at all levels in Vietnam.

With support from the Ford Foundation, the Hanoi School of Public Health carried out an educational intervention in Chi Linh, Hai Duong province, northern Vietnam. The overall goals were to prevent health risk behaviours, to promote sexual and reproductive health and to foster a supportive environment. The intervention trial included assessment of the benefit of strategies to transform gender relations to promote equity. Recent studies have shown the effectiveness of different interventions on adolescent reproductive health in different settings. No study has directly addressed the cost-effectiveness of such interventions.

Objectives

The goal of this research was to examine the cost-effectiveness of three mutually exclusive reproductive health interventions (named level A, B and C) implemented in Chi Linh for adolescents. The specific objectives were:

1. To calculate unit costs (intervention unit costs + health-care unit costs) from the societal perspective associated with three adolescent reproductive health interventions.

2. To construct a decision analytic model to describe the transition to adverse reproductive health states among adolescents and reflect the projected change in both costs and health outcomes associated with implementing the interventions.

3. To use the model to estimate the required effectiveness of the adolescent reproductive health interventions to be supported for widespread adoption, using uncertainty and scenario analysis techniques.

4. To develop recommendations for further data collection to allow local stakeholders to be certain about decisions before investing scarce resources on adolescent reproductive health interventions in other communities.

Methods

Literature relating to reproductive health among adolescents was reviewed, especially to understand health problems and the burden of diseases related to reproductive health, and to give an overview of existing reproductive health interventions in developed countries, developing countries and Vietnam. Published economic evaluations of educational interventions targeting adolescent reproductive health were also reviewed and limitations for decision makers in Vietnam identified.

This research involved the standard techniques of cost-utility analysis and the main outcome measure was cost per quality adjusted life year gained. Primary data on cost, secondary data or estimates based on different assumptions on changes in some primary sexual behaviours, including condom use, number of sexual partners and epidemiological data on adverse reproductive health states and modelling techniques were used. The intervention costs were calculated using two different cost norms: the Ford Foundation and the Vietnam Government cost norms. This study took into account two different cost-norms in order to increase the applicability of the results to the intervention provider team and local stake-holders when deciding whether to implement future interventions funded by international organisations or the Vietnam Government

A Markov state-transition model was developed and subsequently validated by reproductive health clinicians and designers and implementers of preventive interventions. The model was designed to describe the natural history of diseases related to reproductive health issues. The model was used to show how a hypothetical cohort of 100,000 adolescents moved between 11 different health states over time, beginning at the year the intervention commenced (2011) and continuing in 3-month increments. The uncertainty of model input parameters was examined in probabilistic sensitivity analyses and scenario analyses and the value of perfect information was estimated.

The cost-effectiveness analysis evaluated two scenarios:

(1) The existing level of reproductive health education programs for adolescents compared to education intervention level B, which included both school-based and health facility-based components, **without** emphasis on transformation of gender relations to promote gender equity.

(2) Intervention level B compared to level C, which included school-based, health facility-based and community-based components, **with** an emphasis on transformation of gender relations to promote gender equity.

Results

The research confirmed the cost-effectiveness of implementing education intervention levels B and C for a group of males only, for a group of females only and for a group of both males and females in relation to level A. Using the Ford Foundation cost norm, the deterministic analysis and uncertainty analysis revealed that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was cost effective. The incremental cost-utility ratios (ICERs) of intervention level B in relation to level A were AUD4,772/QALY gained, AUD2,988/QALY gained, AUD3,727/QALY gained for male students, female students and a group of both male and female students, respectively. Implementing intervention level C compared to level B was only cost-effective for females or the group of both male and female participants but not for males. The ICERs of intervention level C over level B were AUD8,521/QALY gained, AUD3,332/QALY gained and AUD4,995/QALY gained for male students, female students and both male and female students, respectively.

Using the Vietnam Government cost norm, the deterministic analysis and uncertainty analysis revealed that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was highly cost effective. The ICERs of intervention level B in relation to level A for male students, female students and a group of both male and female students were AUD1,375/QALY gained, AUD590/QALY gained and AUD915/QALY gained, respectively. Implementing intervention level C compared to level B was highly cost-effective only for females and cost-effective for males or the group of both male and female participants. The ICERs of intervention level C over level B for male adolescents, female adolescents and both male and female adolescents were AUD3,708/QALY gained, AUD1,064/QALY gained, and AUD1,911/QALY gained, respectively.

A range of scenario analyses with variations in effectiveness of the education intervention changed the final decision regarding the cost-effectiveness of the different levels of intervention. Using the Ford Foundation cost norm, intervention level B over A would no longer be a cost-effective option if the effectiveness parameters changed to “worse by 5%” for males, “worse by 35%” for females and “worse by 20%” for both male and female participants. Intervention level C in relation to B would not be cost-effective if the effectiveness parameters changed to “worse by 35%” for females and “worse by 5%” for both male and female participants. Intervention level C in relation to B would be cost-effective if the effectiveness parameters changed to “better by 40%” for males.

Using the Vietnam Government cost norm, intervention level B over A would not be a cost-effective option if the effectiveness parameters changed to “worse by 45%” for males, “worse by 70%” for females and “worse by 60%” for both male and female participants. Intervention level C in relation to B would not be cost-effective if the effectiveness parameters changed to “worse by 20%” for males, “worse by 75%” for females and “worse by 50%” for both male and female participants.

Using the Ford Foundation cost norm, for a ceiling ratio value of AUD 5,265/QALY gained, the expected value of perfect information (EVPI) was valued at AUD152,152 for a group of 50,000 males, AUD71,486 for a group of 50,000 females and AUD215,000 for a total of 100,000 males and females. Using the Vietnam Government cost norm, for a ceiling ratio value of AUD 5,265/QALY gained, the EVPI was valued at AUD51,580 for a group of 50,000 males, AUD95,878 for a group of 50,000 females and AUD91,688 for a total of 100,000 males and females. The extremely low value of perfect information at a ceiling ratio of λ = AUD5,265 suggested that the cost-effectiveness of the best choice under current information was already quite clear and not likely to change even under perfect information.

Conclusions

This thesis adds to existing literature on educational interventions for adolescents from a health economics point of view. It is believed to be the first economic evaluation involving a decision modelling technique to incorporate and synthesise the highest level and most suitable information available for the Vietnamese context. The results of this research are expected to assist decision makers in allocating efficiently scare health resources. Current information suggests which level of reproductive health education intervention is cost-effective and should be expanded to other areas for different cost-norms and for different gender-groups of adolescents. Based on this evidence, if the decision makers including the intervention team, Ministry of Health and Ministry of Education and Training, change their current practice of educating adolescents on reproductive health to the best option, costs would be incurred at the lowest amount and health benefits would be brought back to the highest level. Moreover, this research should help to guide researchers and intervention implementers in other settings who need to address similar questions.

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List of abbreviations

AIDS	:	Acquired Immune Deficiency Syndrome
AUD	:	Australian Dollar
CBA	:	Cost Benefit Analysis
CE	:	Cost Effectiveness
CEA	:	Cost Effectiveness Analysis
CEAC	:	Cost-Effectiveness Acceptability Curve
CEAF	:	Cost-Effectiveness Acceptability Frontier
CMA	:	Cost Minimization Analysis
CUA	:	Cost Utility Analysis
DALY	:	Disability Adjusted Life Year
DESS	:	Demographic and Epidemiologic Surveillance System
EQ – 5D	:	EuroQoL five dimension
EVPI	:	Expected Value of Perfect Information
GDP	:	Gross Domestic Product
NMB		Net Monetary Benefit
NMPAYH	:	National Master Plan on Protection, Care, and Promotion of Adolescent and Youth Health
NHB	:	Net Health Benefit
HALYs		Health Adjusted Life Years
HIV	:	Human Immunodeficiency Virus
HSPH	:	Hanoi School of Public Health

HRQoL	:	Health related Quality of Life
IEC	:	Information, Education and Communication
ICER	:	Incremental Cost Utility Ratio
MoH	:	Ministry of Health
USD	:	United States Dollar
PID	:	Pelvic Inflammatory Disease
PSA	:	Probabilistic Sensitivity Analysis
QALY	:	Quality Adjusted Life Year
RCTs	:	Randomised Controlled Trials
RH	:	Reproductive Health
RHIYA	:	Reproductive Health Initiative for Youth in Asia
SAVY		Survey Assessment of Vietnam Youth
SD	:	Standard Deviation
SSASH		Secondary Students and Sexual Health
SRH	:	Sexual and Reproductive Health
STDs	:	Sexually Transmitted Diseases
STIs	:	Sexually Transmitted Infections
WHO	:	World Health Organization
YFS	:	Youth Friendly Services

Statement of original authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature: _ ___

Date: ______11th December, 2014___________

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Chapter 1 - Introduction

This chapter starts by introducing the background of the research (1.1). The introduction of the reproductive health education intervention settings (1.2) as well as the intervention (1.3) are then presented, followed by overall goals and objective of this research (1.4)

1.1. Background

Adolescents and youths in Vietnam aged between 10 and 19 make up 19% of the country's population (Central Population and Housing Census Steering Committee, 2009). The ability of young people to contribute to a nation's productivity and prosperity is dependent on how well they can avoid health risks and chronic diseases, including those associated with sexual and reproductive health. Reproductive health care and prevention programs for young people are prioritised at all levels in Vietnam.

With support from Ford Foundation the Hanoi School of Public Health carried out a project where the overall goals were to prevent health risk behaviours and to promote sexual and reproductive health, as well as to foster a supportive environment for adolescents. This public health project was based at Chililab DESS (a Demographic and Epidemiologic Surveillance System site located in the Chi Linh district at Hai Duong province, in northern Vietnam).

The whole project was to be implemented over 36 months, in three phases. The main objective of Phase 1 was to review previous adolescent reproductive health interventions in Vietnam and to conduct a rapid assessment in Chi Linh to prepare for educational interventions. Phase 2's objective was to conduct a reproductive health education intervention at different levels in seven communes and towns of the Chi Linh district over 12 months, and Phase 3's objective was to scale up the effective interventions to other communes and townships in Chi Linh.

Several recent studies showed the effectiveness of different types of interventions on adolescent reproductive health in different settings. However, there is no study available which directly addresses questions about the cost-effectiveness of these interventions on adolescent reproductive health in Vietnam. At the end of the 12-month intervention phase, an economic evaluation was needed. This research evaluated different levels of adolescent reproductive health education interventions in Vietnam. This research involved the standard techniques of cost-utility analysis and the main outcome measure was the cost-utility ratio, which is cost per quality adjusted life year (QALY) gained. Primary data on cost, secondary data or estimates based on different assumptions on changes in primary sexual behaviours including condom use, number of sexual partners and epidemiological data on adolescent reproductive health (such as unintended pregnancy, abortion, sexually transmitted diseases) and modelling techniques were used in this research.

By doing this, the cost-effectiveness of each level of education intervention could be determined and recommendations regarding whether it should be expanded to other areas made. It is expected that this study contributes to knowledge of cost-effective strategies for preventive, school-based and community-based reproductive health interventions and enhances resource allocation for reproductive health education interventions in Vietnam.

1.2. Introduction of intervention setting - Chililab

Background information

Through an initial grant from the China Medical Board of New York, in 2003, Hanoi School of Public Health (Vietnam) established a Demographic and Epidemiologic Surveillance System (DESS), called Chililab. It is located in the Chi Linh district, at Hai Duong province, half way between Hanoi, Hai Phong - the nation’s busiest port and Quang Ninh – the north east province near the Chinese border. The site was selected because it is on a major transportation route and is transitioning from a rural and semi-rural district to a more industrialised zone. It has been admitted to the international INDEPTH network of demographic surveillance sites since 2004.

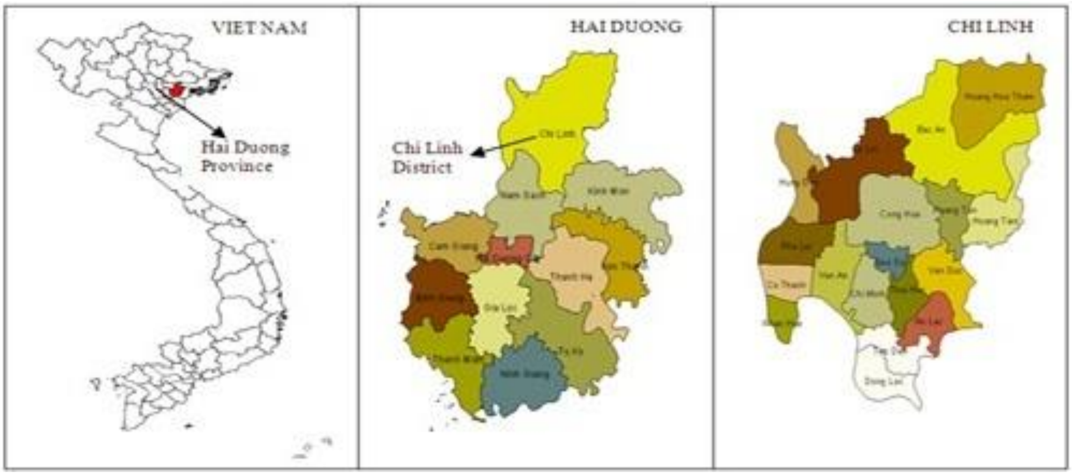


Figure 1: Map of Vietnam, Hai Duong province and Chi Linh

Chililab DESS encapsulates seven of the most rapidly urbanised towns and communes of total 20 communes in the district (Sao Do, Pha Lai, Ben Tam, An Lac, Van An, Le Loi, Hoang Tien). The goal of Chililab is to collect basic demographic and health indicators, on a regular basis, in order to undertake public health research and training activities.

Some facts and figures related to adolescent reproductive health at Chililab

The Ford Foundation provided grant support for the Hanoi School of Public Health to implement three modules on adolescent and youth health at Chililab:

> Module 1: General adolescent and youth health baseline survey – provided an overview of general health status, attitude and behaviours.
>
> Module 2: Risk and protective factors provided the context of different “domains” of adolescent health.
>
> Module 3: Parent connectedness went one-step further in providing an in-depth understanding of a parent-adolescent relationship and its influences upon adolescent and youth behaviours and health outcomes.

Preliminary findings of the Module 1, Round 1 survey at Chililab, conducted in 2006 and early 2007 among all young people aged 10-24, showed that sexual and reproductive health knowledge was a big concern. Up to 40% of adolescents and youths could not identify typical signs of puberty. Across age groups, 57% of those aged 10-14 did not know girls’ puberty signs, compared to 35% in the 15-19 age group and 24% in the 20-24 age group, respectively. Only 49.6% had heard about types of contraception. By age groups: 42.8% in the 10-14 age group knew at least one contraceptive method, compared to 67.9% in the 15 –19 age group, and 82.2% in the 20-24 age group. When asked about the greatest chance of becoming pregnant during the monthly cycle of a woman, only 12.8% of the respondents offered the right answer (Le, Nguyen, Nguyen, & Dao, 2008).

These young people also lacked confidence regarding access to, and use of condoms. About one fourth of the young people reported embarrassment regarding asking for or buying condoms. Only 10% of adolescents and youths felt confident that they knew how to use condoms correctly. The percentage of males who felt confident was 6.8%, 18.1% and 39% in age groups 10-14, 15-19, and 20-24, respectively. Similar percentages for females were 5.7%, 8.6% and 25.9% in age groups 10-14, 15-19, and 20-24. In particular, pregnancy and sexually transmitted disease (STD) prevention practices among adolescents and youths were alarming. Among those who were married, the rate of having premarital sexual intercourse was 23.4% in males and 13.5% in females. Among sexually active unmarried males, 13.4% had made their girlfriends pregnant. Among sexually active unmarried females, 23.8% had been pregnant. The abortion rate among pregnant females was quite high, at 27.9% (Le et al., 2008).

On the base of such evidence, Hanoi School of Public Health developed a quasi-experimental intervention project to promote adolescents and youths' sexual and reproductive health.

1.3. Adolescent reproductive health intervention at Chi Linh – larger project within which the cost-effectiveness analysis was undertaken

1.3.1. Objectives of the intervention

The adolescent reproductive health intervention at Chililab was created and implemented by staff of the Health Behaviour and Health Education department of Hanoi School of Public Health. The overall goal of this intervention program was to foster a supportive environment to address the problems faced by adolescents and youths aged 11-18 by making existing health services more accessible and providing reproductive health and health risk behaviour education to enable them to gain mastery over these behaviours. The specific objectives were to:

- ❖ Improve reproductive health knowledge and attitudes among adolescents and youths.
- ❖ Increase utilisation of reproductive health services for both married and unmarried adolescents and youths.
- ❖ Reduce risky behaviours and improve reproductive health of out of and in school adolescents and youths.

1.3.2. Intervention study design

The project used a multi-sectoral, multidisciplinary approach and a quasi-experimental design. The interventions were designed and implemented within the framework of an operational research study; thus, it was conducted using health facility-based (at primary level, e.g. commune health station), school-based (high school and secondary school) and community-based approaches and settings.

The intervention was implemented over 36 months, in three phases:

- *Phase 1:* Conducted a review of previous adolescent reproductive health interventions in Vietnam and rapid assessment in Chililab to prepare for interventions in 12 months.
- *Phase 2:* Conducted interventions over a 12-month period. After implementing Phase 2, a mid-term evaluation needed to be conducted to prepare for Phase 3.
- *Phase 3:* Adapting or institutionalising and scaling up the effective interventions to other communes and townships in Chi Linh and disseminating experiences and intervention results and materials through different channels to relevant stakeholders to improve policy implementation. This phase continued for 12 months.

In this intervention, seven communes or towns of Chililab DESS were divided into three sites (A, B and C). Site A included one town and two communes, sites B and C included one town and one commune each:

- Site A (one town – Pha Lai and two communes – Le Loi and Hoang Tien): was the control site and did not receive any intervention.
- Site B (one town – Ben Tam and one commune – An Lac): received school-based and health facility-based components, **without** emphasis on transforming gender relations to promote gender equity.
- Site C (one town – Sao Do and one commune – Van An): received school-based, community-based and health facility-based components, **with** emphasis on transforming gender relations to promote gender equity.

1.3.3. Target audience and sample estimation

All secondary and high school students, aged 11-17 (in 2011) and their parents were included as primary and secondary target groups, respectively.

Within Chililab, there are eight secondary schools with 4,247 students and four high schools with 5,726 students. In the intervention area, there are five secondary schools including 2,332 students and three high schools including 4,482 students. Hence, there are a total of 6,814 school students who were beneficiaries of the intervention.

1.3.4. Main activities of the intervention

The intervention had four components:

(1) Training

a. Develop and/or adapt training manuals and communication materials (3 manuals for trainers and 3 manuals for participants)

The training process began with the development and/or adaptation of separate manuals by clinical trainers and social scientists specialising in youth health to train local health workers, school teachers and peer educators. Communication materials such as brochures, leaflets, and toolkits were developed to provide concrete, basic and attractive information for target audiences. The materials were developed using in-country materials (such as the Ministry of Health and Ministry of Education and Training) and international and local non-government organisations as key references. The manual for training health providers focused on youth-friendly attitudes and skills, whereas the manuals for school teachers and peer educators focused more on increasing knowledge, changing attitudes and providing skills to reduce risky behaviours and adopt safer sexual practices. The manual for training school teachers was also used to train peer educators and to expose in school youth to sexual and reproductive health and health risk behavioural issues. These materials were developed and designed with special attention to gender.

Adolescent and youth's reproductive health and life skill building curriculum and communication materials were developed and adapted with the active participation of teachers, parents, program managers and youth. The manuals and materials incorporated the following features: socially acceptable; lively; addressing the needs of both male and female adolescents; enhancing didactic and participatory techniques; introducing topics of priority such as changes during adolescence, sexual relations and sexual abuse, sexually transmitted infections (STIs) and HIV/AIDS, childbirth and family planning, prenatal and postnatal care, along with other equally important subjects like gender issues, and drug and alcohol abuse.

b. Training of health facility service providers (57 local health workers)

District and commune/town health officers in the intervention area selected the service providers for training using criteria presented to them, which included: experience in adolescent service delivery; participation in youth development activities; willingness to perform volunteer work; flexibility and patience with young people; existence of a positive attitude towards adolescents and their sexual health; and a good understanding of adolescent reproductive health. In addition, those making the selections were encouraged to ensure a gender balance if possible. It was intended that for this training, private providers in the intervention area were also identified and invited to participate.

The course content included the following: STI/HIV/AIDS; needs and concerns of adolescents and gender equity; contraceptive update; sexuality and adolescent sexual and risky behaviours; values; communication; counselling; use of visual aids; record keeping; and development of action plans.

c. Training of school teachers (315 school teachers)

University staff trained guidance and counselling teachers and district education department staff, who could then train peer educators. The district education officials and leaders of intervention schools selected participants with certain criteria. The criteria included involvement in youth activities such as sports; drama; willingness to carry out work on voluntary basis; willingness to implement an in school life-skill building program with special focus on reproductive health; some level of understanding of adolescent reproductive health and behaviours and a positive attitude towards adolescent health and sexuality.

The training emphasised the use of participatory methodologies in health education; how to use peer education approaches to increase young peoples' understanding of reproductive health and to promote better health behaviours. Participants worked in groups to develop plans of action. The key highlights of the action plans included debriefing head teachers; conducting orientation meetings for all staff and school committees; advocating for allocation of a guidance and counselling room/friendly youth corner; advocating for allocation of an hour per week in school timetables to be used for life skill building sessions; discussing the project with adolescents between 13-24 years; identification and recruitment of qualified youth to be trained as peer educators; coordinating health club activities and submitting progress reports to the field project coordinator.

d. Training of peer educators (489 peer educators)

The local Youth Union and school-teachers identified peer educators to participate in the project. They were selected on the basis of their likely influence among peers, participation in school and/or community activities, interest in adolescent health, interest in volunteer work and willingness to make time to educate other youth. The local Youth Union worked closely with youth groups and local administration to identify well-mannered and motivated youth to be trained as peer educators. Each intervention school and commune/town identified about 30-40 peer educators. Approximately 7 sessions for in and out of school peer educators were conducted. The trainers from Hanoi School of Public Health participated in training of peer educators to ensure that appropriate methodologies were used and correct information passed on to the participants. There were three training sessions for the out of school peer educators, while each school trained their own peer educators.

Project staff closely monitored all training to ensure they were conducted satisfactorily. Several of the out of school peer educators dropped out and many of the in school peer educators graduated, so the project continued to recruit new peer educators and sought to ensure that the existing ones were properly trained and motivated.

(2) School-based activities

The trained school teachers debriefed their head-teachers and committee members. They discussed the objectives of the intervention and the activities. Meetings were held with the entire teaching staff and the student community and parent association were informed of the project. Those meetings aimed to increase awareness of the project and to solicit support among school personnel. This was crucial because of the controversies regarding sexuality and reproductive health education in schools. The trained teachers embarked on a recruitment drive for suitable students to be trained as peer educators. They introduced and launched health clubs and youth friendly corners in their schools. Youth friendly corners were places that offered youth reproductive health information in an effective, comfortable and attractive way (Pathfinder, 2003).

The trained teachers started to implement the curriculum regarding health risk behaviours and reproductive health. Due to differences in administration, each school applied its own approach for exposing the students to the curriculum. The sessions were held after school hours with individual or combined sessions; alternatively schools used ‘club’ and lesson times available for some subjects, such as physical/biology/civil education.

The schools launched health clubs and friendly corners with trained peer educators. The club members embarked on campaigns to educate their school-mates through group and one-on-one meetings. They received communication materials from the project to enhance their group education sessions. The peer educators referred their colleagues to guidance and counselling teachers and youth-friendly service providers. The teachers helped to organise debates focusing on various reproductive health topics and health risk behaviours.

Guidance and counselling for students was the other key responsibility of trained teachers. After training, the teachers made arrangements with their head teachers to identify and set aside a room where students could be counselled. If it was impossible to allocate a new space, with the school's medical room was one option. This was a sign of commitment and support for the project by the schools. Throughout the project, the teachers provided guidance and counselling to their students and referred cases they could not handle to other teachers and local trained service providers.

Project staff closely monitored all training to ensure that all school-based activities were conducted satisfactorily. Every two or three months, all project teachers met to plan together and share experiences. The sharing encouraged all schools to try new ways of intensifying their education and outreach activities.

(3) Health facility-based activities

After training, service providers held meetings with the health centre management committees and staff to inform them about the project and solicit support for its implementation. Other health facility staffs were also given an orientation on 'providing quality and youth-friendly services' by their trained colleagues. The project coordinator and project trainers participated in these sessions and offered support.

In the four public facilities, health managers of one district hospital and three intervention commune/town health centres allocated rooms, which were refurbished and converted into "youth-friendly" rooms in an appropriate manner. The project installed directional signposts or used other channels to provide information about friendly services and to indicate the services available in those health facilities.

(4) Community-based activities

Trained health care providers in collaboration with the local Youth Union conducted training for out of school peer educators to work in the community. Peer educators operating at the community level were coordinated by the local Youth Union and supported by local governments and health departments. The peer educators conducted individual and group discussions with young people, carried out educational activities in appropriate local settings in an integrated manner with other activities of the Youth Union, visited youth groups, distributed communication materials and made referrals to health facilities. Peer educators used various communication materials to educate and discuss sexual and reproductive health issues with their peers and youth parents. These included videotapes, booklets, and leaflets. They also organised sport activities for out of school youth as opportunities to communicate appropriate messages.

Local mass communication channels such as the commune/town's loudspeakers were mobilised to advocate for the project and transfer basic and relevant messages to local people, especially youth and their parents.

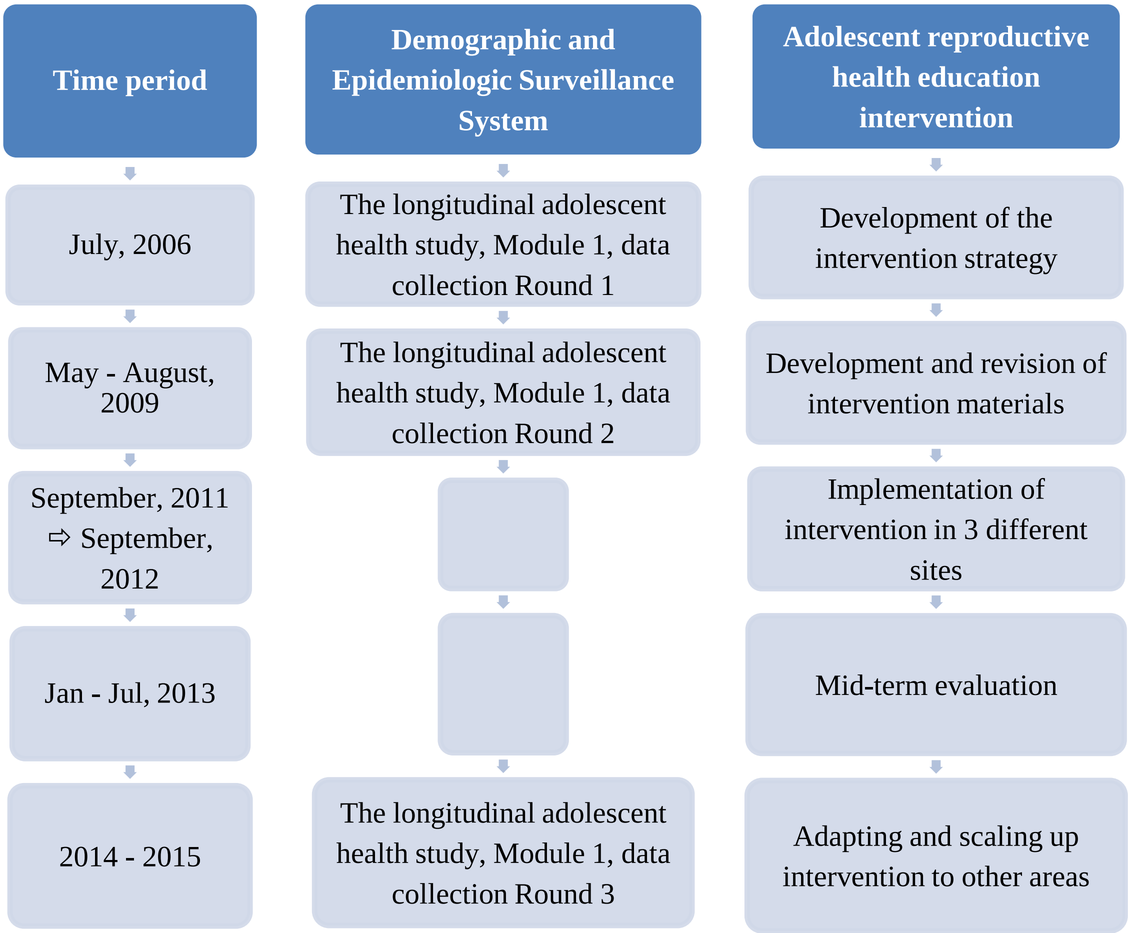


Figure 2: Link between Adolescent reproductive health education intervention and the longitudinal adolescent health study, module 1

1.4. Overall goal and objectives of this project

The goal of this specific project was to examine the cost-effectiveness of reproductive health interventions implemented in Chi Linh.

Evidence synthesis and modelling techniques were used to make transparent the expected cost-effectiveness of the intervention. Results from this research could assist the intervention provider team and local stakeholders to identify whether expansion of the reproductive health education intervention to other areas should be considered.

The specific research objectives were:

1. To calculate unit costs (intervention unit costs + health-care unit costs) from the societal perspective associated with three levels of adolescent reproductive health interventions.

2. To construct a decision analytic model to describe the transition to adverse reproductive health states among adolescents and reflect the projected change in both costs and health outcomes associated with implementing the interventions.

3. To use the model to estimate the required effectiveness for adolescent reproductive health interventions to be supported for widespread adoption, using uncertainty analysis and scenario analysis techniques.

4. To develop recommendations for further data collection to allow local stakeholders to be certain about a decision before investing scarce resources into adolescent reproductive health interventions in other communities.

Research tasks

In order to achieve the above objectives, the following specific tasks were required:

For fulfilment of objective #1:

Task One: Calculate the intervention unit costs from the societal perspective of adolescent reproductive health intervention at all three sites.

Task Two: Calculate the health-care unit costs (e.g. treatment cost for HIV infection, other STDs, PID, abortion and giving birth) from the societal perspective.

For fulfilment of objective #2:

Task Three: Measure health-related quality of life (HRQL) for each health state of interest using primary data combined with existing evidence from the perspective of adolescents in Chi Linh, Vietnam.

Task Four: Construct a decision analytic model to describe the transition to adverse reproductive health related states among adolescents.

Task Five: Identify and synthesise all relevant evidence in order to inform input parameters given the structure of the decision analytic model built in Task 4 to calculate ***the total costs*** and ***the quality-adjusted life years*** of different types of education intervention delivered at the three sites.

Task Six: Elicit expert opinions about the effectiveness of adolescent reproductive health education interventions.

For fulfilment of objective #3

Task Seven: Identify and synthesise the threshold of incremental cost-utility ratio (ICER) in order to classify health care interventions into effectiveness groups in a Vietnamese context, as well as estimate the required effectiveness for adolescent reproductive health interventions to be supported for widespread adoption.

Task Eight: Incorporate uncertainty/sensitivity analysis into the modelling process and quantify the effect of uncertainty on the incremental cost-utility ratio between different intervention approaches of the adolescent reproductive health education intervention in Chi Linh, Vietnam.

Task Nine: Analyse and present simulation outputs from probabilistic models.

For fulfilment of objective #4

Task Ten: Assess the value of perfect information and propose recommendations for further data collection or future research to allow local stakeholders to be certain about an investment of scarce resources into adolescent reproductive health interventions in other communities.

1.5. Outline of thesis

This thesis is organised into eight chapters:

Chapter 1 (this chapter) is an introductory chapter providing the background and rationale for this research. A brief introduction of the education intervention within which this research was done, and the research goals, objectives and specific tasks are outlined.

Chapter 2 is a review of recent literature on reproductive health issues of adolescents, such as sexual behaviours and attitudes, HIV infection and other STDs, unintended pregnancy, birth delivery and abortion. Interventions for preventing these reproductive health problems and studies on the effectiveness of these interventions are summarised.

Chapter 3 is an introduction to economic evaluations in health care. Different methods of economic evaluation, including methods for measuring costs, consequences, and health related quality of life are summarised. The application of economic evaluation into adolescent reproductive health interventions is given.

Chapter 4 reviews the existing cost-effectiveness evidence of reproductive health education interventions among adolescents. It begins with the introduction of the methods used for this review. Description of the interventions and methods used within the economic analyses are provided. Limitations of this evidence for Vietnamese decision-makers are addressed.

Chapter 5 describes the methods used for this economic evaluation. It starts with the overall approach to the evaluation, followed by the development of the economic model and specification of all input parameters. Methods for the model evaluation, including deterministic analysis, probabilistic sensitivity analysis, scenario analysis and value of information analysis are given.

Chapter 6 presents the primary data collection for the estimations of costs, including intervention costs incurred by intervention implementers, and health care costs incurred by health care providers and health care patients and families. The primary data collection for the estimates of health related quality of life and the elicitation of expert opinions regarding the effectiveness of the education intervention are given.

Chapter 7 presents the results of the economic evaluation, including the deterministic analysis, probabilistic sensitivity analysis, scenario analysis and value of information analysis.

Chapter 8 considers the meaning of the results. The findings are interpreted and limitations and strengths of this research are explored. The implications of the economic evaluation results for decision makers and intervention implementers in Vietnam are discussed. The chapter closes with future research recommendations.

Chapter 2 - Literature review on adolescent reproductive health

This chapter starts with a review of recent literature on reproductive health issues of adolescents (2.1). Interventions for preventing these reproductive health problems and studies on the effectiveness of these interventions in other countries and in Vietnam are summarised (2.2 and 2.3).

Although adolescence is generally seen as a period of relatively good health, young people are vulnerable, particularly in relation to their sexual and reproductive health. A wide range of reproductive health education and/or service-provision interventions targeting adolescents have been developed, implemented and evaluated.

2.1. Reproductive health of adolescents

"Reproductive health is a state of complete physical, mental and social well-being and not merely the absence of disease, in all matters relating to the reproductive system. Reproductive health implies that people are able to have a satisfying and safe sex life and they have the capability and freedom to decide their reproductive choices" (United Nations, 1995). This definition of reproductive health was built on the World Health Organization's definition of health in the 1994 International Conference on Population and Development in Cairo, and is widely accepted by scholars and clinicians.

When looking at disability adjusted life years (DALYs) for the adolescent age group, youth appear to be relatively healthy. However, more than 33% of the disease burden and almost 60% of premature deaths among adults can be associated with behaviours or conditions that began or occurred during adolescence, including, sexual and reproductive health related behaviours, tobacco and alcohol use, accidental injury, self-harm and mental disorders (World Health Organization, 2002). The most serious reproductive health problems include human immunodeficiency virus infection (HIV) and other sexually transmitted diseases (STDs), early and unwanted childbearing, pregnancy-related illness and death. These few causes account for a significant part of the burden of disease among adolescents and adults (Glasier, Gülmezoglu, Schmid, Moreno, & Van Look, 2006). Worldwide, sexual and reproductive health conditions account for more than 33% of young women's DALYs and nearly 10% for young men (Lopez, 2006). The burden of reproductive health problems among adolescents in Vietnam is considered to be similar to those worldwide.

2.1.1. Sexual behaviours and attitudes

In the United States, school students reported having their first sexual intercourse at an early age. One study of high school students found that 6% experienced sexual intercourse before the age of 13 (Centers for Disease Control and Prevention, 2009b). Nearly one in five (19.8%) middle school students had experienced sexual intercourse (Centers for Disease Control and Prevention, 2009b). In Australia, the Secondary Students and Sexual Health (SSASH) study reported data on the sexual behaviour of young people aged 15 and 17 years over time, nation-wide, using a repeated cross-sectional methodology. The study showed that the percentage of students aged 15 and 17 who had experienced sexual intercourse had increased from 34% in 1997 to 40% in 2008 (Agius, Pitts, Smith, & Mitchell, 2010). Specifically, a cross-sectional analysis of data from Victorian secondary school students also reported the percentage of students experiencing sex in the past year was 44% (Agius, Taft, Hemphill, Toumbourou, & McMorris, 2013). In Vietnam, the Survey Assessment of Vietnam Youth round 2 (SAVY 2), conducted in 2009, reported the mean age at first sex among youth had decreased to 18.1 years (18.2 years for males and 18.0 for females) compared with 19.6 years in the Survey Assessment of Vietnam Youth round 1 (SAVY 1), conducted in 2004. Youth in rural areas initiated sex slightly earlier (18 years) than their urban counterparts (18.4 years) (Ministry of Health, General Statistics Office, World Health Organization, & the United Nations Children's Fund, 2010). Interestingly, about one in ten (9.5%) respondents aged 14–25 of the SAVY 2 reported that they had premarital sex, a proportion that was higher than the 7.6% found in the SAVY 1. The proportion of males who had had premarital sex was 13.6%, more than twice that of females at 5.2%. Among single youth aged 14-25, 6.4% had had sex, with more males compared with females and more urban than rural youth having done so (Ministry of Health et al., 2010).

The Australian Secondary Students and Sexual Health study reported the likelihood of adolescents having sex with multiple partners had increased significantly in Australia, with the proportion of those reporting sex with three or more people in the previous year rising from 16% in 1997 to 30% in 2008 (Agius et al., 2010). The proportion of all United States high school students who had sexual intercourse with four or more partners over their lifetimes was as high as 14% (Centers for Disease Control and Prevention, 2009b).

Regarding the sexual attitudes of Vietnamese adolescents, among SAVY 2 respondents, 44% of those aged 14–25 (58% of males and 30% of females) had “modern attitudes” about premarital sex compared with 36% in SAVY 1. The highest proportion of youth with the most modern attitude were those over 21 years old (Ministry of Health et al., 2010).

Regarding contraceptive knowledge and use, the Australian SSASH study found that 36% of sexually active adolescents had sex without a condom at last sexual intercourse. This rate had not decreased since 1997 (Agius et al., 2010). Similarly, the study of Victorian secondary school students also found that 34% of those who reported sex in the past year did not use a condom when they last had sex (Agius et al., 2013). Other studies indicated that many students aged 17 did not always use condoms and males were more likely to report using condoms than females. Among Vietnamese adolescents, 92% of respondents aged 14–25 in SAVY 2 knew about oral contraception and 95% were aware of condoms (Ministry of Health et al., 2010). Those proportions were much higher than the 49.6% found in survey at Chi Linh in 2006. The variance is due to the differences in time of data collection between SAVY (in 2009) and the survey in Chi Linh (in 2006) and socio-economic characteristics of respondents in SAVY and in Chi Linh survey.

With regard to attitudes toward condoms, only 38% of respondents in SAVY 2 reported that using a condom could decrease sexual satisfaction. Among the sexually active respondents in SAVY 2, 65% reported that condom use decreased sexual satisfaction compared with 35% of those who had never had sex. Of those who had had intercourse (n=396), half (n=185) said that they had used condoms at first sex. Of those who did not use condoms at first sex, the majority (38% of males and 54% of females) said that they had not wanted to use them; 26% of males and 12% of females said that they had not intended to have sex at that time; and 9% of males and 7% of females said that they had not known how to use them.

2.1.2. Human Immunodeficiency Virus (HIV)

In Vietnam, in 2006, 95.4% of female adolescents aged 15–19 had heard of acquired immune deficiency syndrome (AIDS), 53.4% knew all three ways of preventing HIV transmission while 6.9% did not know any method of prevention. In that report, having comprehensive knowledge of HIV/AIDS transmission was determined as being able to identify two prevention methods and three misconceptions. The result showed that only 45.9% of respondents had comprehensive knowledge of HIV/AIDS transmission (General Statistics Office, 2006). In 2009, SAVY 2 found that 98% of youth had heard about HIV/AIDS, but only 57% of respondents answered all questions about HIV transmission correctly. SAVY 2 data also found that 44.1% of males and 40.8% of females aged 15-24 correctly identified ways of preventing the sexual transmission of HIV and rejected major misconceptions about HIV transmission (Ministry of Health et al., 2010).

Regarding HIV prevalence, 34 million people were living with HIV at the end of 2011 worldwide (Joint United Nations Programme on HIV/AIDS, 2012). In the United States, it was estimated that 1.2 million people were living with HIV infection (Centers for Disease Control and Prevention, 2011) and about 17% of all people diagnosed with HIV/AIDS in 2008 were persons under the age of 25 (Guttmacher institute, 2012). The data available in the United States showed that new HIV infections increased by 21% among adolescents and young adults aged 13-29, from 15,600 in 2006 to 18,800 in 2009 (Prejean et al., 2011). Other reports showed that 76,400 people aged 13-24 were living with HIV infection. It was estimated that about 45,500 HIV-infected youths in the United States were undiagnosed and unaware that they had HIV (Centers for Disease Control and Prevention, 2012). This could create more risk of transferring HIV to others.

In Vietnam, the first case of HIV was diagnosed in 1990 (Ivker, 1996), and since that time, cases of HIV have been identified in all 63 provinces of the country. Although estimates vary, the most widely quoted rate of HIV infections was approximately 0.4% of the general population between the ages of 15 and 49 years. In 2006, the prevalence of HIV among those aged 15–24 was estimated to be 0.9% for males and 0.2% for females (General Statistical Office, National Institute of Hygiene and Epidemiology, & ORC Macro, 2006). Thus, it was estimated that up to 220,000 persons were living with HIV in 2007 (Ministry of Health, 2009; The Socialist Republic of Vietnam, 2008). In 2010, more than 254,000 people were estimated to be living with HIV (The Socialist Republic of Vietnam, 2010). In 2012, up to 280,000 people were estimated to be living with HIV (Joint United Nations Programme on HIV/AIDS, 2012). Specifically, among documented cases, more than half of the HIV/AIDS-infected cases, (e.g. 53.6%), were in young adults between the ages of 15 and 24 (Kaljee et al., 2007).

Regarding burden of diseases globally, HIV/AIDS accounted for almost 9% and 12% of total DALYs for young men and young women ranging in age from 15 to 29, respectively (Lopez, 2006). The burden of HIV/AIDS in young women aged 15 – 29 years was higher than for young men because of their higher levels of susceptibility (UNAIDS, 2009). The “Burden of Disease and Injury” study was carried out in Vietnam in 2008, and showed that HIV/AIDS accounted for about 11% of total DALYs of young males 15 to 29 years of age and 5% of total DALYs of young females aged 15 to 29 years (Nguyen et al., 2011).

2.1.3. Other sexually transmitted diseases (STDs)

In Vietnam, awareness of STIs is a big problem. SAVY 2 data illustrated that STI knowledge remained very low. Among SAVY 2 respondents, 71% had heard of hepatitis B, 64% of syphilis, 62% of gonorrhea and 24% of chlamydia (Ministry of Health et al., 2010)

STDs impose a heavy burden of morbidity and mortality, both directly through their impact on reproductive and child health, and indirectly through their role in facilitating the sexual transmission of HIV infection. The World Health Organization (WHO) (2011) estimated that more than 1 million people acquire a sexually transmitted infection every day worldwide. In developed countries, gonorrhea rates among adolescents were relatively high, especially in the Russian Federation, where the rate was around 600 per 100,000. Moreover, Chlamydia is common among adolescents (between 563 and 1,081 cases per 100,000). In the United States, there were more than 1.2 million cases of chlamydia and more than 300 thousand cases of gonorrhea and among adolescents. The reported incidence of STDs was generally higher among female teenagers than among males of the same age; this is especially true for chlamydia (Centers for Disease Control and Prevention, 2009a). In Australia, more than 50% of school students who used the contraceptive pill did not use condoms to protect themselves from STDs. Estimates suggested that about 28% of Australian teenagers might be infected with chlamydia (Guy et al., 2011).

In developing countries, STDs cause a considerable health and economic burden. In Vietnam, in 2000, about 150,000 new cases of gonorrhea, and 500,000 new cases of chlamydia were estimated (World Health Organization & Regional Office for the Western Pacific, 2000). The number of college students who self-reported STIs increased from 575 cases in 1997 to 7,391 in 2003, which was nearly 13 folds within a short period of six years (National Institute of Dermatology and Venereology, 2003). Data regarding prevalence and epidemiology of STDs might, however, be sub-optimal due to the fact that a significant number of individuals preferred self-medication or visiting private practitioners, pharmacists and drug sellers to accessing public health care services (Chalker, Chuc, Falkenberg, Do, & Tomson, 2000; World Health Organization & Regional Office for the Western Pacific, 2000).

Untreated chlamydia as well as gonorrhea infections, can result in pelvic inflammatory disease (PID), a major medical consequence of sexually transmitted diseases, which in turn leads to chronic pelvic pain, ectopic pregnancy, and infertility (L. Y. Wang, Burstein, & Cohen, 2002; World Health Organization, 2011). Chlamydia infections are asymptomatic in most women and up to 80% of women infected with gonorrhoea are asymptomatic. This raises the probability of developing PID among people with chlamydia or gonorrhea infections. As such, STDs are considered the second most important cause of healthy life lost in women. The Global Burden of Disease and Injury report estimated that syphilis, gonorrhoea, and chlamydia created a loss of 18.6 million DALYs, equivalent to 1.5% of the total calculated global burden of diseases and injuries (Brindis & English, 2004; Murray & Lopez, 1998). Similar data on the specific burden of these STDs is not available in Vietnam.

2.1.4. Unintended pregnancy, birth delivery and abortion

Adolescents are at risk of early and unwanted pregnancy. In the United States, national data available in 2008 showed that the pregnancy rate for teens aged 15-19 was as high as 67.8 pregnancies per 1,000 young women (Kost & Henshaw, 2012; Kost, Henshaw, & Carlin, 2010). Each year, almost 750,000 female adolescents aged 15–19 became pregnant and two-thirds of all teen pregnancies occurred among 18–19 year olds (Guttmacher institute, 2012).

Despite the declining birth rate among adolescents in the United States, it remained as much as eight times higher than in other developed countries (Advocates for Youth). The birth rate for U.S. teens aged 15-19 in 2009 was 3.91%, equivalent to 410,000 females aged 15 – 19. The 2009 birth rate reached its lowest point in nearly seven decades (Martin et al., 2011). In Vietnam, in 2002, it was reported that among adolescents aged15-19, 0.2% had their first birth before 15, 0.6% aged 15-17 years old and 1.0% had their first birth aged 18-19 (Committee for Population Family and Children & ORC Macro, 2002). In 2009, it was reported that the age-specific fertility rate was 2.4% and 12.1% for those aged 15–19 and 20–24, respectively (Central Population and Housing Census Steering Committee, 2009). In 2011 and 2012, it was reported that the adolescent fertility rate for Vietnam was 3% and 2.9%, respectively (The World Bank, 2014).

The adolescent birth-rate has declined in the majority of industrialised countries over the past 25 years (Guttmacher institute, 2012). According to available data on the abortion rate for U.S. teen females aged 15-19 in 2008, there were 14.3 abortions per 1,000 females of that age, and this age group accounted for 16.2% of all abortions (Pazol et al., 2012). Among young women aged 15 – 29 years, illnesses related to pregnancy and childbearing accounted for 16% of their DALYs. Unsafe abortion is an important source of mortality and morbidity for young women, with abortion complications accounting for almost 3% of DALYs worldwide among females 15 to 29 years of age (Åhman, Shah, Butler, & World Health Organization, 2004).

However, this issue is even more severe in Vietnam. Vietnam has one of the highest abortion rates in the world. The abortion rate of married women from 15-49 years in 2005 increased by 0.09% compared with 0.31% in 2002. In terms of age, the highest age of abortion was 25 - 29 (0.40%), the next was 30-34 (0.35%), and the lowest rate was 45-49 (0.22%) (Binh, 2012). Estimates suggested that 44% of pregnancies among young women under 19 years old were terminated. Other reports suggested that abortions by unmarried young women made up between 10% and 20% of all abortions in urban areas (Ministry of Health et al., 2010). Another report showed that the proportion of all pregnancies experienced by youth was as high as 2.9%. Regions with high shares included the Northeast, Mekong Delta, Northwest and Central Highlands. Alarmingly, adolescent abortions among all abortions nationally reached 2.2%, with some regions witnessing very high shares such as the South Central Coast and Mekong Delta (Vietnam Ministry of Health, 2011).

It should be emphasised that data on sensitive issues is often under-estimated in Confucian cultures, such as Vietnam. Conservative sexual mores have predominated and adolescents in Vietnam are often unwilling to reveal their true behaviours (Le, Blum, Magnani, Hewett, & Do, 2006; Mensch, Clark, & Anh, 2003). Hence, the magnitude of adolescent reproductive health problems in Asian countries in general and Vietnam in particular is still a matter of “Iceberg theory”.

2.2. Adolescent reproductive health interventions and their effectiveness

Adolescent reproductive health efforts should include cost-effective prevention strategies. Research in some countries indicated a strong correlation between changes in knowledge, attitudes, behavioural intentions and behaviours (Ajzen & Fishbein, 1980; M. S. Kim & Hunter, 1993; Petty & Cacioppo, 1996; Valente, Paredes, & Poppe, 1998). On this basis, a wide range of adolescent reproductive health interventions that aimed to provide accurate knowledge and foster supportive environment for positive behaviour changes were implemented. Substantial international literature has shown adolescent reproductive health intervention programs were effective in promoting positive knowledge and attitudes and many programs effectively influenced behaviours (Agha, 2002; Grunseit & UNAIDS, 1997; Hardré et al., 2010; Harper, Bangi, Sanchez, Doll, & Pedraza, 2009; James-Traore et al., 2001; Kirby et al., 1994; Walker, 2003).

2.2.1. Adolescent reproductive health interventions and effectiveness in developed countries

Interventions for preventing other sexually transmitted diseases (STDs)

An early review of primary prevention programs for STDs in adolescents aged 10 to 19 years (Yamada, 1999) included a total of twenty-four controlled trials (including 3 RCTs) with 34,281 participants published from 1993 to 1998. Those studies focused on measuring the effectiveness of programs designed to prevent STDs by delaying the onset of intercourse or promoting safe sex behaviours. Those programs could be categorised into different groups: (1) school-based programs, (2) school-based clinics, (3) free standing clinics, (4) practice-based services, (5) community-wide programs, (6) condom availability programs, or (7) other relevant primary prevention programs. However, most of the included studies examined school-based interventions, with 63% focusing on STD education in a classroom setting. Interventions were based on a theoretical framework in most studies (71%), with 13 different frameworks being identified. This review found that improving behaviours in adolescents, in turn protecting against STDs, was possible and neither community- and school-based STD prevention interventions lead to an increase in the number of adolescents who chose to become sexually active, or in the frequency of sexual intercourse. Regarding the implication for future research, none of the studies evaluated the cost-effectiveness of the individual programs.

In 2010, another review (Lazarus, Sihvonen-Riemenschneider, Laukamm-Josten, Wong, & Liljestrand, 2010) was undertaken in order to examine interventions aimed at STI risk reduction and health promotion conducted in schools, clinics, and in the community between 1995 and 2005. Randomized control designs or intervention-only designs were employed to examine change over time and measure behavioural, biologic, or certain psychosocial outcomes in 19 studies. The authors concluded that peer-led interventions were more accepted by youths than teacher-led interventions and peer-led interventions were more successful in improving sexual knowledge.

Interventions for preventing unintended pregnancies

Unintended pregnancy among adolescents represents an important public health challenge in developed and developing countries. Thus, numerous interventions using different approaches to address a wide range of factors related to unintended pregnancies among adolescents have been employed by many agencies at global, regional and national levels. The objectives of these interventions have included: assisting adolescents to reduce psycho-social risk and increase protective factors involving sexuality; promoting teens´ knowledge of risks and consistent and safe use of contraceptives, especially condoms; and skills training to support their social inclusion and personal development. These interventions were designed and implemented in an effort to be practical, evidence-based, culturally appropriate, acceptable for adolescents, and to be able to guarantee good results in terms of goals to be achieved to the satisfaction of all involved, principally adolescents. In order to do so, stakeholders ranging from teens' parents, health-care providers, teachers, and policy-makers stated that interventions should address manifold factors at the same time.

A review was undertaken of secondary-school-based pregnancy prevention programs in the United States by Bennett and colleagues (2005). The review showed that between January 1980 and September 2002, there were 16 randomised controlled trials (RCTs) examining the effectiveness of abstinence-only programs, abstinence-plus programs that incorporated contraceptive information and programs with a focus on the prevention of HIV infection. Those programs enrolled a total of 29,599 participants. The results of this review indicated that the majority of abstinence-plus programs increased rates of contraceptive use, with one study showing effects to last for at least 30 months (Bennett & Assefi, 2005).

Another review (C. R. Kim & Free, 2008) was undertaken of studies in ten countries in North America, sub-Saharan Africa, Europe, Latin America and the Caribbean, and the Middle East and North Africa. The review found thirteen studies published between 1998 and 2005. Of those, four were randomised controlled trials set in developed countries; the remaining studies used quasi-experimental designs. Those studies focused on the effectiveness of peer-led sexual-health education interventions, measured in terms of contraceptive use, use of condom at last intercourse and other behavioural outcomes. The authors concluded that there was no clear evidence on whether peer-led sexual-health interventions had an impact on pregnancy incidence, on having a new partner or on using condoms (C. R. Kim & Free, 2008).

In 2008, a non-governmental organisation, "Advocates for Youth" conducted an exhaustive literature review regarding program effectiveness in the United States. Advocates for Youth selected twenty six programs that met their criteria. These programs strongly affected the behaviours and sexual health outcomes of young people. Of the 26 effective programs, 23 included information about abstinence and contraception within the context of sexual health education. Of the three programs that did not include sexual health education, two were early childhood interventions and one was a service-learning program. The programs were categorised into 3 main groups: (1) school-based programs, (2) community-based programs and (3) clinic-based programs. They were focused on delaying the initiation of sexual intercourse among youth, reducing risk for sexually active youth, increasing use of condoms, reducing the number of sex partners, increasing use of modern methods of contraception, and reducing the incidence of STIs and pregnancy. The review's authors confirmed that high-quality education on sexual reproductive health could have a positive impact on young people's knowledge and attitudes, and some behaviours (Alford, Bridges, Gonzales, Davis, & Hauser, 2008).

Up to December 2008, the Cochrane review (Gilliam, 2010; Oringanje et al., 2009) found 41 prevention interventions which met their inclusion criteria. They were randomised controlled trials to measure the effectiveness of interventions. Those interventions enrolled a total of 95,662 ethnically diverse adolescents, whose ages ranged from 9 years to 19 years. In most interventions, the participants included males and females. As for the settings, only two trials were conducted in developing countries. Most of the trials were conducted in schools. In terms of types of intervention, educational interventions (both sex education and skill-building), contraception methods access or contraception education, as well as multiple interventions (educational and contraceptive promotion) played an important role. The review's authors concluded that although single interventions were not found to be effective, combinations of interventions to improve education and contraceptive access were found to reduce unintended pregnancies among adolescents (Gilliam, 2010; Oringanje et al., 2009). In terms of implications for future research, the need for cost–effectiveness analysis of all proposed interventions was addressed (Ramos).

2.2.2. Adolescent reproductive health interventions and effectiveness in developing countries

A review of experimental and quasi-experimental studies and studies in which change could be attributed to the intervention was undertaken in 2003. Speizer and colleagues (2003) showed that there were forty one studies of different interventions targeting both adolescents (aged 10 to 19 years) and young adults (aged 20 – 24 years). Those interventions could be categorised into different types or settings: (1) school-based programs (education on HIV, AIDS and sexually transmitted infections, general reproductive health education, integrated school and clinic for HIV and general education); (2) mass media programs (media only and media with social marketing); (3) community-based programs (youth development, peer educators and educational programs); (4) workplace programs; and (5) health facility-based programs (youth-friendly services and youth centres). Those interventions involved self-reported sexual and health-seeking behaviour in order to assess effectiveness. The effectiveness of the intervention was focussed on change in knowledge and attitudes, delayed sex, number of partners, contraceptive use and service use. The review's authors concluded that most interventions appeared to have a positive effect on knowledge and attitudes, but the effect on behaviour was less consistent (Speizer et al., 2003). In terms of implications for future research, the authors emphasised the need for further rigorous assessment of adolescent reproductive health interventions.

In 2005, Advocates for Youth conducted an exhaustive literature review of nearly 200 programs in developing countries. They selected only programs with evaluations that showed an impact on sexual behaviours and/or on sexual health outcomes. A total of 10 highly effective programs were identified. All of these programs concerned comprehensive sex education, providing information about abstinence and the use of contraception and condoms. Sexual health services, contraceptive supplies, and/or referral to sexual health services were provided in eight programs. Community members, including parents, religious leaders, health care providers, or youth were actively involved in designing and implementing the programs. Information, education, and communication (IEC) and/or mass media strategies were adopted partially or fully in six programs. The authors concluded that education including information about both abstinence and contraception was the most effective in delaying the onset of first sexual intercourse and in ensuring that young people protected themselves when they became sexually active. The authors emphasised the need for short- and long-term evaluation to determine behavioural and health outcomes of community-driven programs to improve adolescent sexual health (Alford, Cheetham, & Hauser, 2005).

In 2009, Medley and colleagues conducted a systematic review and meta-analysis of peer education interventions in developing countries published between January 1990 and November 2006. Thirty studies were identified. In meta-analysis, peer education interventions were significantly associated with increased HIV knowledge, reduced equipment sharing among injection drug users, and increased condom use. Peer education programs had a non-significant effect on STI infection. The authors concluded that peer education programs in developing countries were moderately effective at improving behavioural outcomes (Medley, Kennedy, O'Reilly, & Sweat, 2009).

In Africa, integration of behaviour change communication interventions in HIV prevention has been widespread, especially in settings with high levels of risk behaviours and low levels of HIV/AIDS awareness (Abdool, Tarantola, As, & Moodie, 1996; Pequegnat & Stover, 2000). However, systematic reviews indicate that inadequate number of economic evaluations exist, especially those that compare the cost-effectiveness of individual components of behaviour change communication programs and those occurring in low and middle income countries (Frick, 2006; Holtgrave, Qualls, & Graham, 1996; Hutchinson & Wheeler, 2006; Walker, 2003). Results from such economic evaluations often provide critical input to policy makers and intervention implementers, particularly in developing countries facing limited resources (Kahn & Marseille, 2000). When behaviour interventions have been found to be cost-effective, in many cases, the effectiveness of the intervention is measured in terms of "population reached" (Piotrow et al., 1992; Robinson & Lewis, 2003; Watts et al., 2000). For example, Justine and colleagues carried out an analysis of the costs to increase awareness and the cost-effectiveness to influence behaviour change for five interventions in Benin. Costs were collected and analysed by “person reached”. Cost-effectiveness was analysed in terms of “person reporting systematic condom use”. The results showed that cost-per-person reached varies by method, with public outreach events the least costly (US$2.29) and billboards the most costly (US$25.07). Cost-effectiveness ratios per person reporting systematic condom use resulted in the following ranking: magazines, radio and public outreach events. The authors concluded that behavioural interventions were context-specific and their effectiveness influenced by a multitude of factors (Hsu et al., 2012).

In 2010, Michielsen and colleagues carried out a systematic review on the effectiveness of HIV-prevention interventions in changing sexual behaviour of young people (10-25 years) in sub-Saharan Africa. Using pre-specified inclusion criteria, they included 31 studies on 28 interventions, including 11 randomised trials. The results showed that condom use at last sex increased only among males [relative risk = 1.46; 95% confidence interval = 1.31-1.64]. One study reported a reduction of herpes simplex virus-2, but not HIV incidence. The authors concluded that more effective interventions targeting youth were needed and attention should go towards studying implementation difficulties, and gender differences in responses to interventions (Michielsen et al., 2010).

In 2011, Mavedzenge and colleagues conducted a systematic review to update evidence on the effectiveness of youth HIV/AIDS prevention interventions in sub-Saharan Africa. During the period between January 2005 and December 2008, a total of 23 eligible studies were published. The authors concluded that school-based, adult-led, curriculum-based interventions showed clear evidence of reducing reported risky sexual behaviour. Interventions in health facilities increased the use of services when they were made accessible and more youth-friendly (Napierala Mavedzenge, Doyle, & Ross, 2011).

2.3. Adolescent reproductive health interventions and their effectiveness in Vietnam

Before 1994

Due to population growth pressure from the 1960s to late 1980s, national family planning programs focused mainly on birth control and providing contraception and reproductive health information to married couples, but not to adolescents and youths (Bondurant, Henderson, & Quoc, 2003). Adolescents had limited access to reproductive health services. A significant number of pregnant adolescents had adverse outcomes. Staff shortages, overcrowded clinics and negative attitudes from providers were barriers to young people seeking health care (Klingberg-Allvin, 2007).

Before the 1990s, national adolescent reproductive health programs were not developed and institutionalised. However, since the early 1990s, various adolescent sexual and reproductive health programs and activities, including school-based and community-based efforts, have been developed and implemented in different areas of Vietnam. The Vietnam Youth Union has played an important role in conducting pilot adolescent reproductive health programs since the early 1990s. Various experimental models for IEC activities, such as clubs for unmarried youth, clubs for young couples, and competitions and contests on population and family planning, were developed and implemented (Khuat, 2003).

From 1994 to 2004

Since the International Conference on Population and Development - ICPD, 1994, many initiatives aimed at reducing health risk behaviours and supporting the sexual and reproductive health needs of young people have been implemented. They included activities to reach young people, both in and out of school, through various information and education approaches, as well as the establishment of youth centres and clinics by government, non-government and community-based organisations, as a means to undertake outreach activities. These interventions focused primarily on promoting reproductive health knowledge, preventing HIV infection and other STDs, and preventing unintended pregnancy.

Since the mid-1990s, HIV/AIDS prevention activities for youth have been actively integrated into adolescent reproductive health programs. Several IEC activities, including “condom cafés,” “counselling cafés”, “green shops,” and “friends-help-friends groups”, were formed and run by the Youth Union at different levels. Between 1995 and 1997, the Women’s Union implemented a three-year project titled “Improvement of Youth Reproductive Health for Young People”. This project aimed at writing books on reproductive health and sexuality education for youth (Khuat, 2003).

In 1996, the Ministry of Education and Training and the Vietnam Red Cross implemented the Life Skills Curriculum for Youth Program in seven provinces and cities with support from the United Nations International Children's Emergency Fund (UNICEF). The program focuses on life skills education and HIV/AIDS prevention. Since 1997, the Ministry of Education and Training has conducted the National Education and Training Program on Reproductive Health and Population Development. The project focuses on teaching young people about reproductive health issues, conducting a distance learning course for all teachers to provide them with information on population and reproductive health, and conducting another course for secondary school teachers to help them teach these sensitive topics. Within the program, counselling centres, hotlines, and IEC mobile teams, are used.

During the period between 2001 and 2005, the Ministry of Education and Training carried out the "Supporting the Population and Reproductive Health Education in the School" project. The objective of the project was to coordinate with other educational activities to increase the knowledge, understanding and improvement of skills relating to reproductive health. To achieve the objective, integration of adolescent reproductive health education in the formal curriculum were requested by the Ministry of Education and Training. To facilitate teachers and schools effectively organising these activities, the "Manual for Organising Extra- curriculum Activities on Adolescent Reproductive Health Education in the Schools" was prepared.

2005 to present

In 2005, Save the Children US, in collaboration with the Student Affairs Department and the Ministry of Education and Training conducted qualitative research on school based reproductive health and HIV/AIDS prevention education in Vietnam (Save the Children, 2007). The Ministry of Education and Training used the research findings to develop an "Action Program for Reproductive Health and HIV Prevention and Education for Secondary School Students for 2007-2010".

From early 2004 to late 2006, Vietnam implemented the Reproductive Health Initiative for Youth in Asia (RHIYA) (Khuat, 2003). The RHIYA in Vietnam targeted both in and out of school youths (10 to 24 years of age) from urban, semi-urban and rural areas with a particular emphasis on gender equity in sexual and reproductive health education and services. Its strategy was to create an enabling environment for policy and advocacy, to encourage young people to adopt more responsible and informed reproductive health behaviours and practices, to improve quality and access to services for youth and to build the capacity of local non-government organisations. During the 33 months of implementation, RHIYA conducted many activities and produced a number of valuable materials, which could be adapted for future interventions, including "Psychology and Physiology of Adolescents", "Friends and Love" and "Things that Young People Should Know about HIV/AIDS" (European Union & United Nations Population Fund, 2006). Although RHIYA generated some important insights and useful materials, there remained a considerable gap in evidence regarding the relative and additional contribution of reproductive health intervention approaches as well as limited evidence regarding how and why interventions did or did not work in certain contexts. The economic aspect of the different intervention strategies, at least from provider perspectives, was not addressed in RHIYA or in other previous programs. Hence, evidence from an economic evaluation of different levels of adolescent reproductive health interventions in Vietnam is necessary.

Following this, in June 2006, the development and promulgation of the "National Master Plan on Protection, Care, and Promotion of Adolescent and Youth Health for the Period 2006-2010 and Strategic Orientation until 2020" (NMPAYH) provided a significant focus to guide interventions to reduce health risk behaviours and to improve the reproductive health status for adolescents and youths (Ministry of Health, 2006). The general objective of the NMPAYH was to maintain and promote the physical and mental health of young people. Specifically, to improve and increase access to quality health care services, especially for sexual and reproductive health and prevention of STDs and HIV/AIDS, to reduce unwanted abortion, to prevent accidents and injuries, decrease the prevalence of substance abuse, and reduce mental health problems. After issuing this policy, in 2007, the Ministry of Health promulgated a "Guideline on Health Friendly Services for Adolescents and Youth" to support implementation of the NMPAYH (Ministry of Health, 2007).

In 2010, the National Target Program on Reproductive Health came into effect. The program provided support for 31 provinces to implement activities in order to improve reproductive health of youth and adolescents. The main focus of the program was maintaining youth-friendly service provision units, as well as activities for adolescent and youth reproductive health clubs and expanding IEC activities (Vietnam Ministry of Health, 2011).

In 2012, three sexual health programs were implemented in 12 communes in Ha Noi, Nha Trang City, and Ninh Hoa District targeting unmarried youth between 15 and 20 years. The three interventions were: (1) Vietnamese Focus on Kids (VFOK), (2) the gender-based program Exploring the World of Adolescents (EWA), and (3) EWA plus parental and health provider education (EWA+). Interventions were delivered over a ten-week period in the communities by locally trained facilitators. The evaluation of the three interventions' effectiveness found that sustained changes were observed in all three interventions for self-efficacy condom use, self-efficacy abstinence, response efficacy for condoms, extrinsic rewards, and perceived vulnerability for HIV (Pham et al., 2012).

Understanding the future needs of adolescent reproductive health in Vietnam

Informing adolescents and youths about appropriate and acceptable behaviours, and ways to protect themselves against abuse and unwanted and unprotected sex has proved problematic in Vietnam. Parents, teachers, community leaders, and health care providers are all expected to educate young people about personal and physical development, about relationships with each other, and about their roles in society, but their capacity to do so in a comfortable, open and unbiased way is clearly lacking. Consequently, many adolescents and youths rely on the media and their friends and peers for sexual and reproductive health information, sources which are notoriously poor at providing accurate and appropriate information.

There is a lack of systematic education programs for both in and out of school young people, controversy and opposition to provision of services to adolescents and youths, and a pervasive concern that provision of sexuality education and contraceptive services will lead to promiscuity. Young people who are sexually active face many barriers to accessing services, thereby reducing their ability to protect themselves. Guidelines for the provision of reproductive health services, and especially contraceptives and condoms, to unmarried adolescents and youths are deliberately ambiguous and open to conflicting interpretation.

This need for information and services for young people must be met if they are to delay becoming sexually active, to resist pressures to engage in non-consensual sex, and to protect themselves against unwanted pregnancies and infections, when they do have sex. The strategies by which such information and services are provided to adolescents will need to be acceptable to even the most conservative groups in Vietnamese society, and in a way that those providing the information and services feel comfortable. Moreover, to be able to reach the majority of adolescents and youths and be sustainable over time, these strategies will have to be developed and implemented by government institutions that already have some responsibilities for serving them.

Gender norms are widely assumed to affect adolescent attitudes, perceptions, and behaviour regarding sexual and reproductive health. Gender norms structure roles for both men and women through their impact on social interactions. Though norms are specific to cultural groups, the fact still remains that across most societies different attributes are assigned to men and women, such as; men are expected to be aggressive in their sexual pursuit while women are expected to be submissive and not to show any signs of interest or knowledge on sexual issues; men's open sexuality is encouraged and women's submissiveness is expected. Norms are learnt from infancy to adulthood; within the home and the society in which one lives. Adolescence is a critical period when one is expected to learn and inculcate the defined norms and roles that are expected to form the individual's values within a given society. Studies carried out in Vietnam reported in a recent review of the United Nations Population Fund (UNFPA) (2007) as well as other parts of the world all revealed that gender norms had an effect on people's perceptions, attitude and behaviour in general. Gender norms also influenced adolescents' attitude to sexual and reproductive health issues as well as their response to intervention activities. Addressing gender concerns relating to youth behaviours requires effort at multiple levels including: challenging gender bias within communities, institutions, and health systems; recognising the impact of family pressure and norms on how girls and boys are socialised into adult roles and fostering positive interactions between boys and girls as they grow into adulthood.

2.4. Summary

Although adolescence is generally seen as a period of relatively good health, young people are vulnerable to health risks, particularly in relation to their sexual reproductive health. The literature showed that reproductive health problems, including HIV infection and other STDs, early and unwanted childbearing, pregnancy-related illness and death, accounted for a significant part of the burden of disease among adolescents and adults.

Research in some countries indicated a strong correlation between changes in knowledge, attitudes, behaviour intentions and behaviours. Thus, numerous education interventions using different approaches to address a wide range of factors related to reproductive health problems among adolescents have been employed by many technical and political agencies in developed and developing countries, including Vietnam. These interventions were designed and implemented in an effort to be practical, evidence-based, culturally appropriate and acceptable for adolescents.

The literature showed that numerous studies have been done in order to measure the effectiveness of these education interventions. However, few cost-effectiveness analyses of these interventions were completed in developing countries, and none in Vietnam.

Chapter 3 - Economic evaluation

This chapter starts by introducing the application of economic evaluation in health care decision making (3.1). The different methods involved in measuring costs (3.2) and consequences (3.3) in health care intervention are then presented, followed by methods used in health related quality of life valuation (3.4) and methods used in economic evaluation (3.5). The next section deals with the application of economic evaluation into adolescent reproductive health interventions (3.6) before the summary is presented (3.7)

3.1. Economic evaluation and health care

Economic evaluations are studies in which a comparative analysis of the costs and consequences of two or more courses of action (such as health care interventions) is undertaken (Drummond, Sculpher, & Torrance, 2005). Given the remarkable rise in health care related expenditures, decision makers have increasingly relied on both clinical effectiveness and economic efficiency when making health care decisions. For instance, in Australia, economic evaluation has been required for public sector funding of all new drugs (Palmer, Byford, & Raftery, 1999; Raftery, 1998).

The rationale for economic evaluations is clear. First, it is obvious that resources – people, time, facilities, equipment and knowledge – are scarce and choices must be made. Second, both efficacy and efficiency have been increasingly taken into account by decision-makers when deciding which choice to make (Drummond et al., 2005; Hauck, Smith, & Goddard, 2003; Raftery, 1998; Saint, Chenoweth, & Fendrick, 2001; Shiell, Donaldson, Mitton, & Currie, 2002). As a result, the literature reveals substantial growth in the application of economic evaluations over different disciplines of health care. The value of economic evaluation has been proved in both preventive interventions, such as infection control (Saint et al., 2001), influenza prevention (Burls et al., 2006), and vaccination (Jacobs & Meyerhoff, 2003) and curative interventions, such as mental health problem treatments (Singh, Hawthorne, & Vos, 2001) the treatment of chronic hepatitis C (Shepherd et al., 2004) and the treatment for chronic hepatitis B (Kanwal et al., 2005).

There are four major types of economic evaluations: cost-benefit analysis, cost-effectiveness analysis, cost-utility analysis and cost-minimisation analysis (Drummond et al., 2005). The method used to measure and value the consequences of an intervention makes the most significant difference between these major types.

(1) Cost Minimisation Analysis (CMA) is the simplest type of economic evaluation. CMA is used when the benefit of the intervention of interest and the comparator are equal, in other words, similar in measurement units as well as magnitude (Drummond et al., 2005; Palmer et al., 1999; Shiell et al., 2002). However, Drummond et al. (2005) suggested that it was not appropriate to include CMA as a type of full economic evaluation. They referred to the study of Briggs and O'Brien (2001) which indicated that because of the uncertainty around costs and benefits of given studies, "CMA is not a unique study design that can be determined in advance". Drummond et al. (2005) also added that CMA could only be applied in situations where two options are of almost identical technology, like drugs of the same pharmacological class.

(2) Cost-Effectiveness Analysis (CEA) is a comprehensive economic evaluation which compares both costs and consequences of alternatives. This technique compares interventions with a common outcome (such as blood pressure level) and shows the cost per unit of health gain (Drummond et al., 2005). Costs in CEA are identified and measured in a way similar to that of CMA, while consequences are expressed in physical units such as number of patients treated, life-years gained or number of days without diseases or specific syndromes (Drummond et al., 2005; Tan-Torres et al., 2003).

CEA is widely used because of its direct comparison of intervention alternatives. Moreover, measuring costs in monetary units and results in physical units makes the analysis useful for both service users and providers. However, there are some limitations of CEA, such as: (a) inability to compare interventions which have more than one kind of health outcome, (b) inability to compare interventions which have different terms of measurement, (c) and not taking into account non-health effects, such as those related to society (Drummond et al., 2005; Gold, 1996; Tan-Torres et al., 2003).

(3) Cost-Utility Analysis (CUA) is an economic evaluation technique, closest to CEA. In CUA, costs are calculated in the same way as CEA and utility units measuring changes in both quantity and quality of life are used to measure consequences (Drummond et al., 2005; Palmer et al., 1999). Two common measures of population health which combine both quantity and quality of life into a single unit are the ‘quality-adjusted life year’ (QALY) and the ‘disability-adjusted life year’ (DALY). Some pros and cons as well as applications of these two health measures, are discussed further in a separate section (see 3.3 and 3.4).

While CEA focuses on the effect of treatment measured in a single natural health unit, Drummond et al. (2005) stated that CUA had the advantage of evaluating health outcome in terms of both quantity and quality of life. CUA is appropriate in situations where quality of life is “the” or “an” important outcome of health care (Torrance, 1986), and when it is necessary to have a common unit of measurement to compare between different types of interventions with different target outcomes, such as curative and preventive interventions, or which produce multiple health benefits (Tan-Torres et al., 2003). CUA is often considered a form of CEA where the health outcome incorporates quality of life into the analysis. When using CEA or CUA, in order to enable decision making, the maximum willingness-to-pay λ, sometimes termed as “a ceiling ratio” is required. The identification of λ involves the valuation of health gain in terms of money.

(4) Cost-Benefit Analysis (CBA) measures both the costs and consequences of interventions in monetary terms, and presents the net gain or loss as a cost-benefit ratio (Garber, Weinstein, Torrance, & Kamlet, 1996).

As the consequences of alternatives are measured in monetary terms, CBA can be used to compare different health programs (such as cessation programs for drug users and vaccination programs for children) or programs in different disciplines (for instance education, health or construction). Moreover, it can evaluate one single program by determining its net social benefits. The net social benefit of the single program is equal to sum of direct benefits (which are the savings in health care costs because the program makes people healthier and they consequently use fewer health care resources) and indirect benefits (which are the production gains to society because more people are well or alive, and able to return to work) minus the sum of direct costs (which are the costs of physicians’ time, hospitals, drugs and other health care costs) and indirect costs (which are the cost of lost production, if any, because the patients participate in the program, e.g. extra time off work to receive the intervention) (Torrance, 1986).

However, CBA is not commonly used by health researchers due to ethical and methodological issues. Translating individual health outcomes into dollar terms seems controversial for two reasons: firstly, whether it is ethical to do so and secondly, which value is true. It is worth noting that people's willingness to pay for their health might differ widely due to a number of factors, including income, occupation, education, marital status etc. For example, wealthier people may have a higher willingness to pay for medical care than those who are poor because they judge their opportunity costs of getting sick or dying as much higher. These factors have also been shown to vary greatly between studies (Hauck et al., 2003).

3.2. Measuring costs in health care intervention

Costs of a health care intervention can be categorised into different groups (Drummond et al., 2005; Torrance, 1986):

(1) Direct costs include intervention staff compensation and field staff compensation (for example physicians' salary or educators' salary), facility-related costs (rent, utilities), materials (videos, condoms, syringe sterilization kits, printed matter such as pamphlets, etc.) and general overheads (often assessed as a fixed percentage of the organisation's operating expenses).

(2) Indirect costs include opportunity costs associated with the participants' participation in the intervention and cost of transportation, meals and accommodation if required for taking part in the intervention. The opportunity cost associated with the participants' participation in the intervention often makes up the largest part of the indirect costs. Valuation of the opportunity cost of participants involves the valuation of participants' time, which might otherwise have been spent in other productive (compensated) labour, or in leisure activities. Forgone employment time should be valued at prevailing wage rates, possibly adjusted for geography or for the age and gender of the participant. Leisure time is typically valued at between half the prevailing wage rate and full compensation (Gold, 1996). However, in some prevention interventions, participants are provided with monetary incentives for taking part in the intervention. Such incentive payments can be used as a proxy for the opportunity costs of participation, in that the participant accepts this level of compensation in lieu of other remuneration (Pinkerton & Holtgrave, 1998).

(3) Side effect costs are the costs of any intervention-induced effects, whether beneficial or detrimental to participants, which should also be incorporated into the estimate of total intervention costs. For example, a sexual risk reduction intervention will have an obvious side expense; the cost of the additional condoms used by intervention participants (Pinkerton & Holtgrave, 1998).

In general, costing resources classified as “direct costs” involves three steps: identifying, measuring and valuing all resources used for health care intervention (Raftery, 2000).

(1) Identification of resources used covers two topics: identifying the types of resources used that are relevant for the intervention and deciding upon the level of detail that has to be measured and valued (Oostenbrink, Koopmanschap, & Rutten, 2002).

(2) Measurement of resources used is the practice of assigning appropriate measurement units for the resources used and documenting the right quantities of units of the resources used (Drummond et al., 2005).

(3) Valuation of resources used requires correct unit costs or prices to be identified and total cost to be calculated by multiplying the quantity by the relevant prices. Unit costs used in the valuation process can be from primary or secondary sources (Mogyorosy & Smith, 2005).

In addition to implementing these steps, there are other factors that need to be taken into account.

(a) Viewpoint or perspective: it is essential to specify the viewpoint because an item may be a cost from one point of view, but not from another. For example, patients’ income loss due to sick leave is a cost from the patient’s point of view, but not a cost from the hospital’s point of view. The analysis can be conducted from various viewpoints or perspectives which can be classified as patient (first party), provider (second party), purchaser or payer (third party), employer or other sponsor (fourth party), government, and societal perspective (Mogyorosy & Smith, 2005). Defining the objectives of the study allows researchers to select the most appropriate perspective. In general, the societal viewpoint is the appropriate one for public policy decision making (Torrance, 1986). Normally, the “societal perspective” includes all costs and impacts across all sectors of the economy, irrespective of who is affected (Torrance, 1986). A societal perspective would thus include impacts on non-health sectors (such as education, food supply, police/courts, production gains/losses in the broader economy), in addition to the health sector impacts (such as the government as the health service funder, patients and their family members). The inclusion of non-health sectors may be important for some diseases or risk factors that involve interventions outside the health sector, such as illicit drugs, alcohol or obesity prevention (Anderson et al., 2007).

(b) Time horizon: is defined as the period of time when all relevant costs and consequences should be determined. Ideally, the time horizon should be chosen in such a way that all costs and consequences of the disease can be taken into account in the analysis (Brouwer, Niessen, Postma, & Rutten, 2005).

The time horizon for the provision of a health promotion intervention will vary according to the nature of the intervention. The time horizon for tracking the associated costs and cost offsets should reflect a period as long as costs and benefits continue to accrue. The consequences of preventive intervention will often extend over the lifetime of the target population.

(c) Discount rate: the choice of discount rate is relatively important because it has a substantial impact on the study results. The discount rates, as recommended by the World Health Organization guide (Tan-Torres et al., 2003), are 3% or 5%. The choice of rate is important as shown by Riewpaiboon et al (2007) who found that a change of discount rate from 3% to 6% resulted in a 4.76% increase of the hospital's total annualised capital cost. The prevalence of a 5% rate in the existing literature has the advantage that different studies are comparable, at least on this methodological dimension (Riewpaiboon, 2008). However, some argue that 5% may not consistently reflect societal or individual preferences and 3% would be the most appropriate real discount rate for costing as well as economic evaluations. Therefore, the best possible way to present results on costing is to present costs in their undiscounted form, or in other words, 0% discount rate and to use the discount rate of 3% and 5%.

(d) Economic versus financial or accounting costs: economic and accounting assessments apply different costing methodologies. One fundamental concept in economics is opportunity cost – by choosing to use available resources in one way, we sacrifice other opportunities to use those same resources. Therefore, economic cost or opportunity cost of engaging in an activity or producing a product refers to the sum of all other benefits that can be generated by the same amount of resources taken away for this activity (Berger, Hedblom, Pashos, & Torrance, 2003). On the other hand, accountants measure costs by the historical outlay of funds. So, accounting cost is the acquisition price of a product. An example of potential differences between the accounting and the economic approach in valuing resources consumed is the costing of capital assets. The accounting approach uses the historical acquisition price; the economic approach uses replacement value.

Economic or opportunity cost is the first priority used in costing as well as economic evaluation (Berger et al., 2003). However, in practice, market prices (charge from price list) with appropriate adjustment can be applied as a reasonable proxy of opportunity costs (Mogyorosy & Smith, 2005).

3.3. Measuring consequences in health care intervention

To estimate the consequences from health care interventions, data can be derived from a single randomised trial or a single observational study. Other data sources can be clinical opinions and expert panels, although they are often considered less rigorous or non-scientific sources of information for outcome assessment. Data gained from large scale, multicentre trials are widely considered the best, but these types of data are not always available. The estimated intervention benefit derived from a single study is of concern to researchers and policy makers regarding its accuracy and precision. Ideally, several studies of the same interventions (treatment and comparator) within a similar population from which to determine an average benefit will be considered as the "second best" option. Several economic evaluations have indeed used meta-analysis to estimate intervention effects (Saint et al., 2001).

The consequences of a health care program can be measured in three main types of unit, which are (1) natural health unit, (2) health adjusted life years (HALYs) and (3) monetary terms.

Health outcome measured as natural units refer to units that are natural to the program or disease, for example: cases found, cases prevented, disability days prevented, hospitalisation-days prevented, lives saved, or life-years gained. This type of health outcome measure could be used in cost-effectiveness analysis.

On the other hand, health has long been internationally evaluated by mortality-based indicators, such as life expectancy, all-cause and disease-specific mortality, infant mortality, death rates, etc. Although mortality-based rates are useful in a cursory way, they provide insufficient information with which to make basic judgments about the health of a population or the comparative impact of an intervention. The contribution of chronic disease, injury, and disability to population health thus goes under-estimated (Gold, Stevenson, & Fryback, 2002).

Health outcome measured as health adjusted life years (HALYs)

In addition to the length of life, quality of life is also of importance. This fact has resulted in efforts to develop new, generic methods for the estimation of treatment results that also take into account patient preferences (Räsänen et al., 2006). To solve the problem of comparability of measurements, health economists have introduced the concept of health-adjusted life years (HALYs). HALYs are summary measures of population health that allow the combined impact of mortality (length of life) and morbidity (quality of life) to be considered simultaneously. This feature makes HALYs useful for comparisons across a range of illnesses, interventions, and populations. HALY is a series of measures, including disability-adjusted life years (DALYs) and quality-adjusted life years (QALYs) (Gold et al., 2002). For health economists, the QALY and DALY have been widely used and are preferred as they offer the additional advantage of incorporating preferences for health outcomes, thereby moving beyond the narrow biomedical model for evaluative research (Petrou & Gray, 2011a). This type of health outcome measure could be used in cost-utility analysis.

QALYs were developed in the late 1960s by economists, operations researchers, and psychologists, primarily for use in economic evaluation (Fanshel & Bush, 1970). It has become increasingly common for economic evaluation in health and medicine to measure effectiveness in terms of QALYs gained (Neumann, Zinner, & Wright, 1997). QALYs calculation is based on a series of "quality weights" of health states, which is one type of health related quality of life (HRQL) weights, where the quality weights reflect the desirability of living in the state. A higher weight reflects a better or more preferred state; generally, a health state is rated on a scale in which a weight of 0.0 corresponds to death and a weight of 1.0 corresponds to good health or best attainable health. QALYs can be estimated using the following equation:

$$\sum \textit{QALYS} = \sum \textit{Quality weight for each state} \;\; X \;\; \textit{Time spent in each state}$$

For example, if someone spends two years in a health state with quality weight of 0.8, the QALYs of this person will be 0.8 x 2 = 1.6 QALYs.

The QALY framework provided a basis for the development of a number of health outcome measures, including the disability-adjusted life years (DALYs) in the early 1990s (Sassi, 2006).

DALYs were developed to quantify the burden of disease and disability in populations, as well as to set priorities for resource allocation. DALYs were first introduced in the World Development Report (World Health Organization, 1993) and the Disease Control Priorities Review (Bobadilla et al., 1993) as a method of estimating the global burden of disease and as an outcome measure for use in cost-effectiveness analysis. In 1996, a second version of DALYs was developed to replace the earlier construction (Murray & Lopez, 1996a, 1996b) and was used in the Global Burden of Disease series (Mathers, Fat, & Boerma, 2008).

DALYs are the sum of the present value of future years of lifetime lost through premature mortality, and the present value of years of future lifetime adjusted for the average severity of any mental or physical disability caused by a disease or injury (Rushby & Hanson, 2001). DALYs, therefore, measure the gap between a population's health and a hypothetical ideal for health achievement (Gold et al., 2002).

DALYs	**=**	**YLL**	**+**	**YLD**
⇩		⇩		⇩
Disability-adjusted life years		*Years of Life lost due to premature death*		*Years Live with Disability*

The most important part of DALY calculation is the "disability weight", which reflects the average severity of the disease compared to full health and death. After the classification of diseases, injuries and their sequelae on the basis of the ninth revision of the International Classification of Disease (ICD-9) (1975) into 107 causes of death and 483 disabling sequelae, disability weights were assigned to each sequelae using an expert panel, which derived weights using person trade-off methods. It is worth noting that the DALY incorporates an age-weighting function assigning different weights to life years lived at different ages and the origins of disability and quality of life weights differ significantly (Sassi, 2006).

Generally, there are three steps involved in the calculation of health-adjusted life years (HALYs): (a) describing health, i.e., as a health state or as a disease/condition; (b) developing values or weights for the health state or condition, which are called HRQL weights; and (c) combining values for different health states or conditions with estimates of life expectancy (Gold et al., 2002).

In summary, both QALYs and DALYs are used to express the effectiveness of health care as a combination of a change in both the length and quality of life. Although QALYs and DALYs stem from the same broad conceptual framework, they are not interchangeable as they are based on different assumptions (Sassi, 2006). Moreover, eliciting quality weights and disability weights used for the calculation of QALYs and DALYs are different. During recent years, the QALY has been recognised as the most important indicator of the effectiveness of healthcare interventions (Räsänen et al., 2006). This recognition is reflected, for instance, in the standpoint of the National Institute of Health and Clinical Excellence (NICE), providing national guidance on treatments and care for those using the National Health Service (NHS) in England and Wales, which uses the QALY as its principal measure of health outcome (Rawlins & Culyer, 2004). Different approaches to measuring the value of health improvement through QALYs will be reviewed in considerable detail in the next section.

Health outcome measured as monetary units, refer to measurement of economic benefits associated with health improvement caused by the programs or an individual's willingness to pay or willingness to receive. The willingness to pay approach was first proposed by Drèze in 1962, and values the amount of money that an individual would be willing to pay to purchase the health improvement as a result of the health intervention, everything else being equal, if that level of health improvement were available on the market. A closely allied approach is the willingness to receive, which values the amount of money that an individual would be willing to receive, everything else being equal, in compensation for the health decrement. The willingness to pay or receive approaches determine a monetary value which can be used in a cost-benefit analysis, however, these approaches have proved difficult to implement in practice (Klarman, 1982; Muller & Reutzel, 1984).

3.4. Methods used in health related quality of life (HRQL) valuation.

The morbidity or quality of life component of health-adjusted life years (HALYs) is referred to as health-related quality of life (HRQL), which includes "disability weight" and "quality weight" used for the calculation of DALYs and QALYs, respectively. QALYs differ from DALYs in some points, including the aspects of health that are valued, the populations from which values are gathered, and the techniques for ascertaining the HRQL values.

In DALYs, measurement of preferences or values such as “disability weight” are captured on a scale of 0.0 to 1.0, representing the extremes of full health and death, and can be obtained through an iterative, deliberative process involving groups of health professional experts (convenience samples of World Health Organization and affiliated health workers were used rather than gathering community data in multiple locations for measurement procedure of “quality weight”) using a single technique for value elicitation (Murray & Lopez, 1996a). The person trade-off approach was utilised for the disability weight elicitation on a series of 22 “indicator” health conditions selected to represent different dimensions of disability and non-fatal health outcomes.

On the other hand, in QALYs, measurement of preferences or values as “quality weight” is captured on a scale of 0.0 to 1.0, representing the extremes of death and full health and negative values representing health states worse than death. This can be done in two ways, ***(1) direct measurement*** and ***(2) indirect measurement*** (Arnold, Girling, Stevens, & Lilford, 2009). The former can be performed for discrete condition-specific health states and the latter can be performed by applying utility algorithms to generic or disease-specific preference-based questionnaires, or by mapping from a disease-specific health-related quality of life instrument onto the utility algorithms of a generic instrument. Regarding direct measurement, preferences, or values are generated by a number of techniques. The most commonly used methods include standard gamble, time trade-off, and rating or visual analogue scales (Dolan, Gudex, Kind, & Williams, 1996; Torrance, 1986). In general, health economists support the use of choice-based methods (standard gamble and time trade-off) over the visual analogue scales. On one hand, the standard gamble approach is relatively time-consuming and it is not easy for respondents to understand the concept of probabilities (Dolan et al., 1996; Torrance, 1986). On the other hand, the time trade-off approach is a reliable and practical middle way, despite the fact that the trade-off concepts may still not be easy for many respondents to understand (Dolan et al., 1996; Torrance, 1986). The choice of different approaches can lead to differences in “quality weight” estimates. A review of utilities across 995 chronic and acute health states illustrated strong evidence for visual analogue scales to yield the lowest, time trade-off the middle and standard gamble the highest values for the same health states (Morimoto & Fukui, 2002).

On the subject of indirect measurement, the multidimensional HRQL questionnaires developed using multi-attribute utility theory (MAUT), have been valued by a general public sample. This type of questionnaire can be categorised into: (1) non-disease-specific health states or (2) disease-specific utility instruments. They are both based on a combination of general attributes. There are some common generic utility instruments, including the EuroQoL five dimension (EQ-5D) (Williams, 1990), the Short Form six dimension (SF-6D) (Brazier, Roberts, & Deverill, 2002), the Health Utilities Index mark 2 and mark 3 (HUI2 and HUI3) (Feeny et al., 2002; Torrance et al., 1996), the Quality of Well-Being (QWB) (Kaplan, Anderson, & Ganiats, 1993), and the 15 dimension (15D) (Sintonen, 2001). One instrument of the researchers' choice will be presented in a form of a simple questionnaire and used to ask the public respondents to value a limited number of health states of interest. In turn, a scoring algorithm is developed using econometric modelling (if the instrument of researchers' choice is EQ-5D and SF-6D) or a multiplicative multi-attribute utility function (if the instrument of researchers' choice is HUI) to predict values or preferences for other health states not directly valued (Tolley, 2009). Examples of disease-specific utility instruments include the International Prostate Symptom Score (IPSS) for benign prostatic hyperplasia (Kok, McDonnell, Stolk, Stoevelaar, & Busschbach, 2002), the International Index of Erectile Function (IIEE) (Stolk & Busschbach, 2003), the Cambridge Pulmonary Hypertension Outcome review (CAMPHOR) (McKenna, Ratcliffe, Meads, & Brazier, 2008), the Rheumatoid Arthritis Quality of Life Questionnaire (RAQoL) (Marra et al., 2005), the Health Assessment Questionnaire (HAQ) and the Recurrent Genital Herpes Quality of Life scales (RGHQoL) (Doward et al., 1998).

As the indirect measurement approach is often easy to administer, it is commonly utilised as the source of quality weightings in economic evaluation. A systematic literature review was done in 2006 with the aim to identify which HRQL instruments were used to calculate QALYs in published studies (Räsänen et al., 2006). The result showed that across the available instruments, the most frequently used instrument was EQ-5D (47.5% of all eligible research found). Other instruments used were HUI (8.8%), QWB (6.3%), and SF-6 D (5.0%). Of these studies 23.8% used the direct valuation method: time trade-off (10.0%), standard gamble (5.0%), visual analogue scale or rating scale (8.8%). Similarly, in 2009, a review and empirical analysis was undertaken in order to make a comparison of direct and indirect methods for estimating health state utilities for resource allocation (Arnold et al., 2009). The review showed that for direct utilities, standard gamble alone was used in 23 of the 83 comparisons, time trade off alone in 26 and both in 34, for indirect utilities, the most popular instruments were EQ-5D (n=67) and HUI-3 (n=37). Specifically, within this review, three studies were found using EQ-5D instruments over the hypothetical patients (which means respondents were asked to imagine the experience of the health condition) to value 15 different health states. This finding shows that the EQ – 5D questionnaire has been used on respondents who are not actually experiencing the health states of interest.

As mentioned above, a systematic review showed that across these available instruments developed for assessment of HRQL, the most frequently used instrument was EQ-5D (Räsänen et al., 2006). EQ-5D was developed by the EuroQoL Group in 1987 (Cheung, Oemar, Oppe, & Rabin, 2009; Williams, 1990). The EQ-5D defines the state of general health across five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension has three levels: no problems, some problems, severe problems. The combination of these categories theoretically results in 243 unique health states, plus dead and unconscious, to make up a total of 245 health states and provides an estimate of a health summary score - the EQ-5D index - on a scale where 1 is full health and 0 is deceased.

EQ-5D is designed for self-completion by respondents and is suited for use in different formats, such as postal surveys, clinics, and face-to-face interviews. It is cognitively undemanding, taking only a few minutes to complete and including instructions for respondents (Räsänen et al., 2006). The respondent is asked to answer a simple questionnaire, which consists of two pages, a five-item descriptive system of health states on one page and a visual analogue scale on the other page. To date, there are more than 150 official language versions of the EQ-5D questionnaire, including Vietnamese. The respondents in these types of survey could be “current patients”, who are actual patients with direct experience of a certain condition, or “hypothetical patients”, who are asked to imagine the experience of the health condition (Arnold et al., 2009). Literature suggests that in order to be considered reliable, the minimum sample size for population-based studies should be 100 respondents (Tolley, 2009).

Results from the questionnaire can then be converted into a utility index score by using scores from value sets (preference weights) elicited from a general population. The best-known preference weights were derived from samples of the United Kingdom population, which is the original used for estimating EQ-5D index scores.

In addition to the United Kingdom weights, a number of other countries have their own population-based preference weights for the EQ-5D, such as the United States, Germany (Claes, Greiner, Uber, & Graf von der Schulenburg, 1999), Denmark (Wittrup-Jensen, Lauridsen, Gudex, Brooks, & Pedersen, 2001), Spain (Badia, Roset, Herdman, & Kind, 2001), Japan (Tsuchiya et al., 2002) and Thailand (Tongsiri & Cairns, 2011). EQ-5D valuation sets can be used across countries, even where countries do not have their own (Sakthong, Charoenvisuthiwongs, & Shabunthom, 2008). However, evidence suggests that there could be variations in the valuations of health states for people in different countries due to differences in demographic backgrounds, social-cultural values, and economic systems (Badia et al., 2001; Busschbach et al., 2003; Guillemin, Bombardier, & Beaton, 1993; Sakthong et al., 2008). Therefore, it is advisable to use country-specific weights in a given country if available. However, preference weights of EQ-5D for Vietnamese people are not yet available. As valuation of the EQ-5D health states, which is representative for the whole country, is often complex, time-consuming, and expensive, applying other existing preference weights is essential if they are not presently available in the country. Fortunately, countries with available population-based EQ-5D references include Korea and Thailand, and with regard to cultural dimensions, South Korea has close scores to Vietnam (Bailey & Kind, 2010). In 2010, the time trade-off preference value set of South Korea was already being used successfully in research in order to evaluate the quality of life among older people in rural Vietnam (Hoi, Chuc, & Lindholm, 2010).

3.5. Methods used in economic evaluation

There are two main methods used for an economic evaluation: collecting cost and consequence data alongside a clinical trial or using the decision analytical modelling technique.

(1) Randomised Controlled Trials (RCTs). RCTs offer analysts an opportunity to evaluate resources used, as well as health benefits in order to estimate the short term cost-effectiveness of interventions under real world conditions (A. Briggs, Sculpher, & Claxton, 2006b; Petrou & Gray, 2011a). RCTs could be pragmatic trials or explanatory trials (Petrou & Gray, 2011a). There are some advantages to conducting economic evaluations based on RCTs, such as providing comparative data with high internal validity, an early opportunity to produce reliable estimates of cost-effectiveness at low marginal cost, or to permit a wide range of statistical and econometric techniques to examine further relation between events of interest and health outcomes (Petrou & Gray, 2011a). Thus, economic evaluations of either clinical or surgical treatments, screening or prevention, as well as health and educational interventions, are increasingly conducted alongside RCTs (Villar & Carroli, 1996).

However, RCTs also have some disadvantages. First, a single trial might not compare all available options, provide evidence on all relevant inputs, or be conducted over a long enough period to capture differences in economic outcomes (Sculpher, Claxton, Drummond, & McCabe, 2006). Second, reliance on a single trial may mean ignoring evidence from other trials, meta-analyses, and observational studies (Petrou & Gray, 2011b). Third, extrapolation of the results gained from one specific setting to other settings or to a longer time period might be impossible and biased (Buxton et al., 1997). Additionally, it might be neither financially nor ethically acceptable to undertake long-term or large scale RCTs. Therefore, RCTs do not always provide sufficient information in order to meet the requirements of decision-making (Petrou & Gray, 2011a; Sculpher et al., 2006). Due to the RCT limitations discussed above, decision analytical modelling is considered an alternative method for economic evaluation.

(2) Decision analytical modelling. Modelling is increasingly used as an alternative method for representing the complexity of the real world in a more simple and comprehensive way (Buxton et al., 1997). Modelling techniques offer many advantages. First, models can help analysts to extrapolate beyond the period observed in a trial or the data observed in the trial where pragmatic considerations limit the range of outcome data collected. Second, models can enable analysts to link intermediate clinical endpoints to long-term outcomes. In addition, models can help analysts to generalise the results from trials to regular practice or from one setting to other settings. Finally, models can facilitate analysts even when the magnitude of key variables is unknown and implementation of trials is impossible. Thus, economic evaluation of health care interventions based on decision analytic modelling is increasingly used as a valuable method of providing information to aid health policy decision-makers efficiently (A. Briggs & Sculpher, 1998; Buxton et al., 1997; Hunink, Glasziou, Siegel, & et al, 2001).

Unfortunately, models have some drawbacks, as they are built on a wide range of assumptions. Moreover, the results of a decision analytical model are subject to the influences of variability, parameter uncertainty, structural or model uncertainty, and finally heterogeneity (A. Briggs, 2005; Petrou & Gray, 2011b). Hence, handling uncertainty analysis carefully when decision analytical modelling technique is used becomes a crucial process of economic evaluation.

These two methods for conducting economic evaluation have positive and negative elements. There has been a long history of debate regarding the applications of either method. Research shows that there is considerable complementarity between modelling and trial methods within economic evaluations. For instance, models are typically used where the clinical trials measure intermediate endpoints or have only short-term follow-up, then statistical models are used to extrapolate beyond the trial to final endpoints such as survival (Buxton et al., 1997). That is the case of this study as only the intermediate effects of the reproductive health education intervention, such as changes in knowledge, attitudes and behaviour intention among adolescents, could be measured using the expert elicitation approach. Models were thus used to predict the final expected health outcomes, which were changes in the rates of STDs acquired, unwanted pregnancies, or abortions.

Representations of decision analytical modelling

Models used in the prognosis for health problems can be categorised into two main groups, models based on independent individuals and models that account for interaction between individuals (P. Barton, Bryan, & Robinson, 2004).

(1) Models based on independent individuals include the two most common types of models: decision trees and Markov models

Decision trees are the simplest and the most transparent form of decision analytical modelling (Petrou & Gray, 2011b). Conversely, there are several shortcomings with this model. Firstly, the time at which the events occur are not specified through the model. Secondly, the structure implies that events of interest do not occur more than once. This issue could be solved by using a recursive decision tree. However, the recursive model is only easy to manage for a very short time horizon (Sonnenberg & Beck, 1993). In general, if the time horizon is short and the mortality of patients does not differ across events and the assumption of independence between patients is satisfied, a decision tree is considered to be appropriate (P. Barton et al., 2004)

Markov models provide a means of prognosis for health care problems in which risk is continuous overtime, events may occur more than once and the time at which the event occurs has an important effect on the expected outcome. Markov processes are categorised according to whether the state-transition probabilities are constant over time or not. If the state transition probabilities are constant over time, a special type of Markov process, called a Markov chain, will be used to calculate the expected cost and health benefit using Matrix Algebra (Sonnenberg & Beck, 1993). Otherwise, the most common type of Markov process, a time-dependent Markov process, is used. In this case, a Markov cohort simulation or Markov cycle tree is adopted to calculate the final cost and health benefit (Sonnenberg & Beck, 1993). Although Markov models alone or in combination with decision trees are the most common models used in economic evaluations, there are other approaches available.

(2) Models involving interaction between individuals, such as discrete event simulations and dynamic models, have been used to evaluate many aspects of health care, including hospital scheduling and organisation, and communicable diseases and screening (P. Barton et al., 2004; Fone et al., 2003). Discrete event simulations describe the flow of individuals through health care processes, in relation to their characteristics (such as age, sex, disease history) and outcomes over unrestricted time periods, hence, work at an individual level (Brennan, Chick, & Davies, 2006; Petrou & Gray, 2011b). Dynamic models take into account some forms of interaction between individuals and allow internal feedback loops and time delays that affect the behaviour of other target populations within a study (Petrou & Gray, 2011b).

Both discrete event simulation models and Markov processes are forms of simulation. Discrete event simulations are dynamic simulations where the clock advances from one event to the next and are sometimes. They often sample from probability distributions to calculate time to event. Monte Carlo simulations on the other hand usually are defined as repetitive trials by generating random numbers. (P. Barton et al., 2004).

Each representation mentioned above has its own advantages and disadvantages. The simulations (Markov cohort, cycle tree, Monte Carlo) allow the analysts to assign transition probabilities and incremental utilities that vary with time. A disadvantage to all simulations is the requirement for repetitive and time-consuming calculations (Sonnenberg & Beck, 1993).

Uncertainty in economic evaluation

Variability refers to the differences that occur between patients by chance, which has been referred to as first-order uncertainty in some medical decision-making literature (Stinnett & Paltiel, 1997). Heterogeneity refers to the differences that occur between patients that can be explained, such as age or gender. In contrast to the variability and the heterogeneity, decision uncertainty is the fundamental quantity that needs to be captured within the decision models. There are two forms of uncertainty that can occur: parameter uncertainty and structure or model uncertainty.

(1) Parameter uncertainty occurs due to sample variation around estimates of variables, for instance; unit costs or epidemiological parameters, or potential bias within the data collection system or uncertainty around social value choices, such as health state preferences or discount rates (Tan-Torres et al., 2003). This type of uncertainty has sometimes been termed second-order uncertainty to distinguish it from first-order uncertainty (or variability) (A. Briggs et al., 2006b). In order to address these problems, probabilistic sensitive analysis, based on a large number of Monte Carlo simulations examining the effect on the results of an intervention when the variables are allowed to vary simultaneously across a range according to predefined distribution, would be useful (Drummond et al., 2005; Tan-Torres et al., 2003).

(2) Structure or Model uncertainty is related to mathematical equations used to combine parameters into a model to calculate prognoses for costs and benefits (Drummond et al., 2005) and the assumptions underpinning the model. In other words, model uncertainty is where the structure of the model may not be a good approximation of reality. It is not easy to incorporate explicitly into analyses, although it is still important and must be considered in interpretation. There may be two methods to deal with this problem (Manning, Fryback, & Weinstein, 1996). The first is applying a qualitative approach by computing the cost effectiveness ratio under two or more modelling techniques. The second is to adopt a quantitative technique, computing a weighted average of the result estimates, with the weights reflecting the degree of confidence in each alternative model (Manning et al., 1996).

Uncertainty/sensitivity analysis in economic evaluation

Uncertainty/sensitivity analysis involves systematically examining the influence of change in the value of the input parameters on costs and effects on the intervention (Drummond et al., 2005). It is a useful technique for investigating the influence of variables and assumptions used in a model as well as the relationship between input parameters and model outcomes (A. Briggs & Gray, 1999). It encompasses several alternative approaches.

(1) One way sensitivity analysis examines the impact of each variable on the final results while holding other variables constant, e.g. “ceterus paribus” condition, at their “best estimate” or baseline value (A. Briggs & Gray, 1999; Walker & Fox-Rushby, 2001). For example, one way sensitivity analysis can be used to quantify the range of incremental cost-effectiveness ratios in which the discount rates of costs and health effects are varied between 0%, 3% and 5%.

(2) Extreme scenario analysis involves assigning each variable to simultaneously take the most optimistic and pessimistic value in order to generate a best and worst case scenario (A. Briggs & Gray, 1999). For example, extreme scenario analysis can be used to quantify the best and worst values of incremental cost-effectiveness ratios in which the discount rates of costs and health effects are as high as 20% or as low as 0%.

(3) Probabilistic sensitivity analysis is likely to produce results that lie between the ranges gained from one way sensitivity analysis and extreme scenario analysis, and may thus produce a more realistic estimate of uncertainty (Manning et al., 1996).

To examine the impact of uncertainty on the final results, Monte Carlo simulation modelling techniques are often used to present uncertainty around each incremental cost-utility ratio that reflect all of the main sources of uncertainty in the calculations. In order to do so, estimates and assumptions of input parameters need to be entered as probability distributions. The choice of probability distributions around the input parameters are presented in the following tables (adapted from Briggs et al (2006b)). Due to the *Central Limit Theorem*, normal distribution could be applied for any model parameter.

Table 1: Possible probability distributions around the input parameters

Parameter	Form of data and method of estimation	Candidate distribution
Probability $(0 \le \pi \le 1)$	Binomial/Multinomial: estimated proportion/s Time to event: survival analysis	Beta(α,β),α,β>0 Dirichlet(α1,…αk),αk>0 Lognormal(lm,lv),lm,lv>0
Cost $(0 \le \theta \le +\infty)$	Weighted sum of resource counts: mean	Gamma(α,β),α,β>0 Lognormal(lm,lv),lm,lv>0
Utility decrement/ Disutility ((0 ≤ θ ≤ 1)	Continuous non-zero: mean	Gamma(α,β),α,β>0 Lognormal(lm,lv),lm,lv>0
Or Utility	Continuous non-zero: mean	Beta(α,β),α,β>0
Other parameters	Any distribution of data	Normal(μ,σ²), σ²>0

(Source: adapted from Briggs et al (2006b))

As listed in the above table, distributions for probability parameters are Beta (Dirichlet) for binomial (multinomial) data when counts of the events of interest plus its complement are available. In such cases, if the data are represented by a number of events of interest *r,* observed from a given sample size *n*, then the point estimate of the probability is the proportion of events to the total sample, uncertainty in this probability could be represented by a Beta(α,β) distribution, in which $\alpha = r$, $\beta = n - r$ (A. Briggs et al., 2006b). However, secondary data are sometimes used. An approach known as "method of moments" is used to fit the beta distribution given the mean or proportion and standard error or variance that is reported. For θ ~ Beta(α,β), the moments of the Beta distribution are given by:

$$E(\theta) = \frac{\alpha}{\alpha + \beta}$$

$$var[\theta] = \frac{\alpha * \beta}{(\alpha + \beta)^2(\alpha + \beta + 1)}$$

With given sample moments μ and σ^2 then α and β can be calculated using this following equation:

$$\alpha = \mu(\alpha + \beta)$$

$$\beta = \alpha \frac{(1 - \mu)}{\mu}$$

Similarly, distributions for costs data will be ideally Gamma, which is parameterised as Gamma(α,β). The method of moments is also used as follows:

$$\theta \sim Gamma(\alpha,\beta)$$

$$\mathrm{E}[\theta] = \alpha\beta$$

$$\mathrm{Var}[\theta] = \alpha\beta^2$$

The approach is again to take the observed sample mean and variance and set these equal to the corresponding expressions for mean and variance of the distribution:

$$\mu = \alpha\beta$$

$$\sigma^2 = \alpha\beta^2$$

With given sample moments μ and σ^2 then α and β can be calculated using the following equation:

$$\alpha = \frac{\mu^2}{\sigma^2} \qquad \beta = \frac{\sigma^2}{\mu}$$

Once distributions are fitted around model parameters, values are drawn randomly from these distributions, using the Monte Carlo simulation. This is a straight forward repetitive process and can be achieved in Microsoft Excel using programs known as "macros".

The model is recalculated on the spread sheet many times (usually 1,000) - each time picking a value out of all defined probability distributions - and a full record of all the probabilistic output of the probabilistic model is established.

Presentation of uncertainty in cost-effectiveness analysis

There are different ways to present uncertainty analysis in economic evaluation, especially presenting simulation output from a probabilistic model, such as a cost-effectiveness plane, interval estimates for cost-effectiveness ratios, a net-benefit framework, cost-effectiveness acceptability curves (A. Briggs, 2005; A. Briggs, Sculpher, & Claxton, 2006a; A. Briggs et al., 2006b) and cost-effectiveness acceptability frontiers (G. R. Barton, Briggs, & Fenwick, 2008).

The cost-effectiveness plane shows the difference (treatment minus control) in effectiveness against the difference in cost, which is created by plotting all possible values of the effectiveness difference on the horizontal axis and all possible values of the cost difference on the vertical axis. The plane can be defined as four separate quadrants, which are labelled north-west (new treatment dominated), north-east (trade-off), south-west quadrant (trade-off) and south-east quadrant (new treatment dominates) (Black, 1990). Normally, the threshold ratio, λ, sometimes termed as "a ceiling ratio", the maximum willingness-to-pay by decision-makers, will be added to the cost-effectiveness plane and the joint density will show if the intervention is cost-effective.

Figure 3 is an example of such a plot showing the uncertainty results of incremental costs and incremental QALYs as the "control" compared "with the treatment". Moreover, the threshold ratio, λ, is added to the cost-effectiveness plane and the joint density shows if the treatment is cost-effective, for example, if 90% of point estimates are below the threshold ratio, it means there is a 90% chance that the treatment is cost-effective.

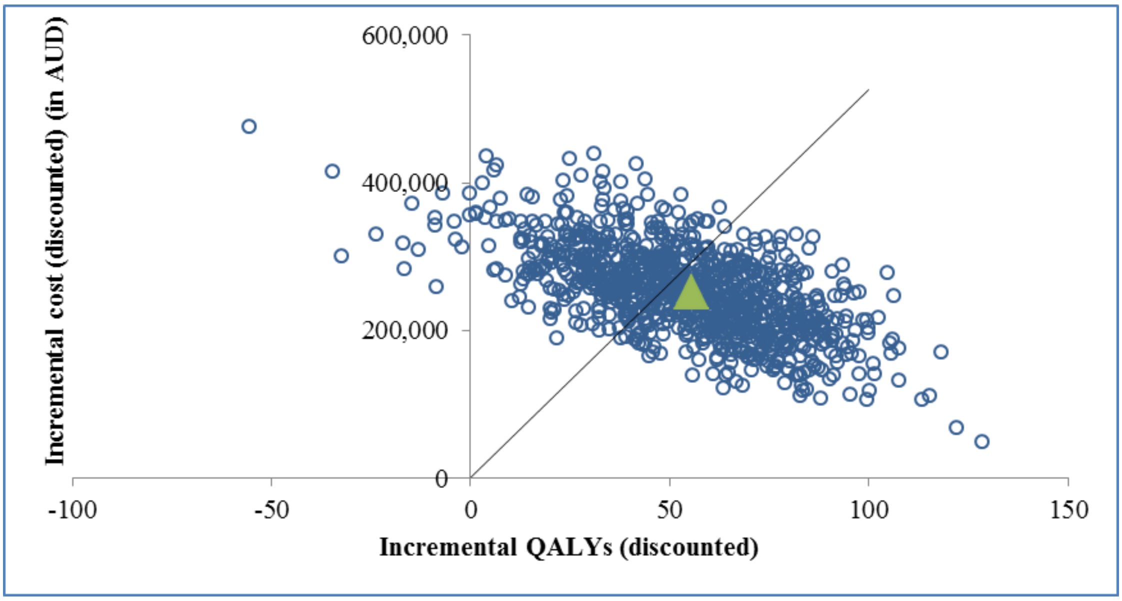


Figure 3: Example of uncertainty cloud on Cost-effectiveness plane

Interval estimates can be obtained for cost-effectiveness ratios using the simulation results by using the percentile method. This simply involves taking the α/2 and (1-α/2) percentiles of the simulation vector as the (1-α)100% uncertainty interval for cost-effectiveness ratios (A. Briggs, 2005; A. Briggs et al., 2006b). For example, if a 95% uncertainty interval for cost-effectiveness ratio, (β,θ), is reported, it means there will be a 95% chance that the cost-effectiveness ratio of that intervention will lie between β and θ.

When there is a high level of uncertainty surrounding a strategy and uncertainty covers several quadrants on the cost-effectiveness plane, the sole use of ICERs may result in incorrect interpretations. For example, negative ratios of the same magnitude in the north-west and south-east quadrants have precisely the opposite implication as the decision rule in the north-west quadrant is “alternative dominated”, which is the opposite of that in the south-east, “alternative dominates”. Therefore, the concept of net monetary benefit (NMB) is also important. The net-benefit framework is shaped by rearranging the algebraic formulation of the decision rule for cost-effectiveness analysis. The rule is that a new treatment should be adopted only if its incremental cost-effectiveness ratio lies below the threshold ratio:

$$\boldsymbol{ICUR} = \frac{\sum \boldsymbol{Cost\ 1} - \sum \boldsymbol{Cost\ 2}}{\sum \boldsymbol{QALY\ 1} - \sum \boldsymbol{QALY\ 2}} = \frac{\Delta \boldsymbol{C}}{\Delta \boldsymbol{E}} < \boldsymbol{\lambda}$$

Claxton and Posnett (1996), Tambour et al. (1998) and Claxton (1999) rearranged the formulation of the decision rule on the cost scale (net monetary benefit, NMB) as follows:

$$\boldsymbol{NMB} = \boldsymbol{\lambda} * \Delta \boldsymbol{E} - \Delta \boldsymbol{C} > 0$$

Where $\Delta \boldsymbol{C}$ and $\Delta \boldsymbol{E}$ represented the incremental costs and incremental health benefits, respectively and $\boldsymbol{\lambda}$ is the decision maker’s ICER threshold.

Moreover, Stinnett and Mullahy (1998) rearranged the formulation of the decision rule on the benefit scale (net health benefit, NHB) as follows:

$$\boldsymbol{NHB} = \Delta \boldsymbol{E} - \frac{\Delta \boldsymbol{C}}{\boldsymbol{\lambda}} > 0$$

A positive NMB or NHM means that an intervention is cost-effective and a negative NMB or NHB means that this intervention is not cost-effective.

The cost-effectiveness acceptability curve (Van Hout, Al, Gordon, & Rutten, 1994) directly summarises the evidence (i.e. probability) in support of the intervention being cost-effective (i.e. acceptable) for all potential values of the decision rule (i.e. threshold ratio,λ) based on the calculation of NMB and NHB. The threshold ratio, λ, is then varied in order to create a graph; namely the cost-effectiveness acceptability curve (CEAC), which shows the probability of each analysis scenario being cost-effective (vertical axis) at different values of the threshold ratio for a unit of health outcomes gained (horizontal axis).

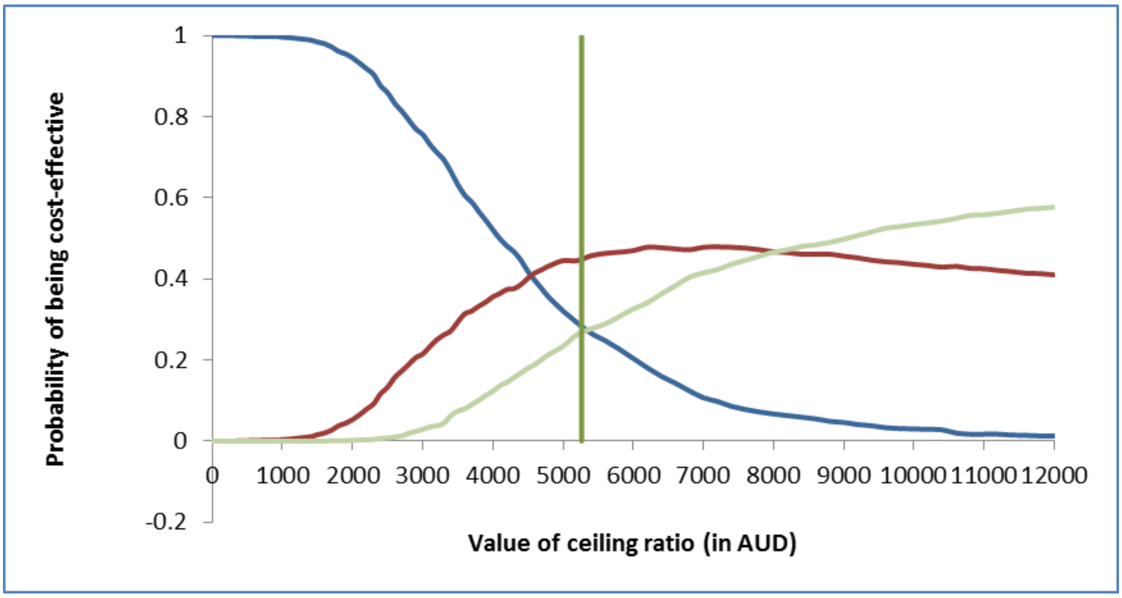


Figure 4: Example of the cost-effectiveness acceptability curves

In the case of multiple options, a separate CEAC can be plotted for each option (A. Briggs et al., 2006b; A. H. Briggs, Goeree, Blackhouse, & O'Brien, 2002). Multiple CEACs graphically illustrate the results for different levels of treatment. Figure 4 is an example of multiple CEACs.

Barton and colleagues (2008) suggested that in the case of mutually exclusive options, the CEAC should not be used to identify the optimal treatment option. Instead, the use of the cost-effectiveness acceptability frontier (CEAF) is proposed by Fenwick and colleagues (2001). CEAF plots the uncertainty associated with the optimal option, for different values of the cost-effectiveness threshold. This is equivalent to plotting each CEAC over the range of values for the cost-effectiveness threshold for which each option is estimated to be the most cost-effective, i.e., has the highest incremental cost-effectiveness ratio falling below the threshold. Figure 5 is an example of a CEAF.

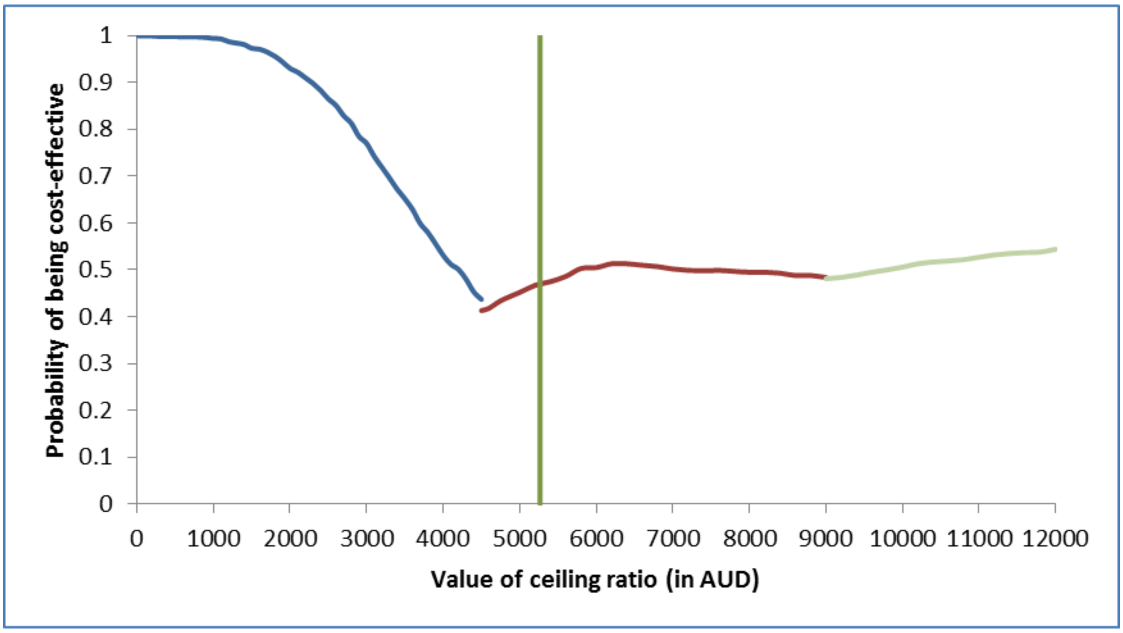


Figure 5: **Example of the cost-effectiveness acceptability frontier**

3.6. Application of economic evaluation to adolescent reproductive health interventions

Economic evaluations have been applied in developing countries, such as Mexico, India and some east and northern African countries. Especially, since the World Bank Health Sector Priorities Review and the CHOosing Interventions (that are Cost-Effective project (WHO-CHOICE)) have been using cost-effectiveness analysis to assist in setting health care resources' priorities (Adam et al., 2005; Hutubessy, Chisholm, & Edejer, 2003; Tan-Torres et al., 2003). In Vietnam, the project on evidence base for health policy (VINE) was established to build local capacity for research to inform policy including mortality analysis, burden of disease and cost-effectiveness analyses. Within that project, some economic evaluations were undertaken which offered a set of cost-effective interventions for some major topic areas, such as diabetes prevention, tobacco control, schizophrenia treatment, hypertension prevention and treatment, etc. (Hill, 2011).

Economic evaluations have been widely applied in the discipline of reproductive health on a number of alternative medical treatments or prevention strategies of adverse outcomes related to reproductive health, such as, HIV/AIDS infection, other STDs, abortion or giving birth.

To start, a number of interventions targeting HIV risk behaviours were shown to be effective based upon experimental and quasi-experimental studies (Pinkerton &

Holtgrave, 1998). To maximise the impact of public spending on HIV prevention, program managers, community planning groups and other decision makers need accurate information on the economic efficiency (i.e., the relative balance between costs and consequences) of alternative HIV prevention strategies. That is why economic evaluation techniques, including cost-benefit, cost-effectiveness and cost-utility analysis, are increasingly used for the assessment of HIV prevention interventions (Pinkerton & Holtgrave, 1998). From 1995 to 1998, in the United States, a total of 73 economic evaluations of HIV prevention interventions were published in abstracts and the peer-reviewed literature, 28 of which could be classified as behaviour change interventions (Holtgrave et al., 1996).

As it is seldom feasible to evaluate the effectiveness of a HIV prevention intervention directly (such as changes in the incidence of infection), behavioural change measures are often relied upon (Pinkerton & Holtgrave, 1998). Converting these behavioural outcomes into an estimate of the number of infections prevented by the intervention is required for the calculation of a cost-effectiveness ratio (cost per HIV infection averted) or estimation of the number of QALYs lost when someone becomes infected with HIV. A Bernoulli-process model (Pinkerton, Abramson, & Holtgrave, 1998) has been adapted in a series of cost-effectiveness studies of HIV prevention programs (Guinan, Farnham, & Holtgrave, 1994; Holtgrave, 1998; Holtgrave & Pinkerton, 1997). For instance, in order to estimate the health outcome of a state-wide social marketing campaign in Louisiana designed to increase condom use by increasing the accessibility of condoms, the Bernoulli-process model was used to translate self-reported sexual behaviours and prevailing epidemiological conditions into an estimate of the number of potential HIV infections prevented by the intervention (Bedimo, Pinkerton, Cohen, Gray, & Farley, 2002). More recently, to evaluate the outcome of the city of Houston school-based HIV/STD prevention program, Ateka and Lairson (2008) also used the Bernoulli-process model to estimate program effects. Application of the Bernoulli-process model in Louisiana and Houston may indicate that it is suitable and plausible to apply this model for estimating the health outcomes of school-based reproductive health education interventions.

Regarding STDs, a systematic review of economic evaluation and modelling of chlamydia trachomatis screening showed that 57 formal economic evaluations and two cost studies were conducted up to August 2004 (Roberts, Robinson, Barton, Bryan, & Low, 2006). Regarding analytical approach, thirty four studies used decision tree models, two used Markov chain models, one used a Markov model, one used a dynamic model, two used discrete event simulations, one used an unspecified simulation model and twelve studies used no model. Roberts et al. (2006) indicated that the validity of these economic evaluations could be threatened due to methodological issues. First, the static modelling approach, such as decision trees and Markov models, which assume a constant probability of infection, is inappropriate for the study of infectious diseases. This modelling approach cannot take into account the impact of re-infection or continued transmission. Second, policy recommendations drawn from economic evaluations using restricted outcomes such as "cost per case detected", might not be useful as they do not provide any indication of the final success of the intervention. Last but not least, uncertainty associated with probability estimates for the long term sequelae associated with chlamydia infection has not been handled carefully in most studies. To address the issues discussed above, further studies regarding infectious diseases should adopt a model involving interaction between individuals, such as discrete event simulations and dynamic models, in order to fully evaluate the impact of re-infection, continued transmission and the change in prevalence over time due to education or screening programs.

With regards to pregnancy prevention, an economic evaluation examined the cost-effectiveness and cost-benefit of Safer Choices - a school-based HIV, other STDs and unintended pregnancy prevention intervention for high school students in the United States (L.Y. Wang, Davis, Robin, Coyle, & Baumler, 2000). The Bernoulli-process model was used to translate increases in condom use into estimated cases of HIV averted and also cases of other STDs averted. Following this, Wang et al. developed a pregnancy model to translate contraceptive use into cases of unplanned pregnancy averted. The results showed that the Safer Choices program was cost-effective and cost-saving in most scenarios considered. This study, indeed, demonstrated how economic evaluation could be applied to a primary prevention intervention targeting adolescents.

However, in comparison with burden of disease, the literature showed that economic evaluations on adverse outcomes related to unintended pregnancy and child birth were still quite rare. According to a survey of cost-effectiveness research on preventive intervention, in 2008, 232 economic evaluations of prevention interventions were published worldwide (van Gils, Tariq, Verschuuren, & van den Berg, 2011). Most studies focused on the prevention of infectious diseases (73 studies) and cancers (49 studies), cardiovascular diseases (23 studies), mental and behavioural disorders (16 studies) and on diseases of the musculoskeletal system and connective tissue (15 studies). Fewer evaluations focused on pregnancy, child birth and abortion.

Moreover, the results from a census of economic evaluations in health promotion indicated that since 1990, there have been over 400 economic evaluations of health promoting interventions in the peer reviewed and grey literatures. However, there are very few studies examining the cost-effectiveness of the intervention's settings of interest, for example, school as a crucial setting for addressing health issues of school-aged children (Rush, Shiell, & Hawe, 2004) as well as the capacity to intervene effectively at this setting, for instance, reproductive health. The paucity of economic assessment studies of prevention programs in general and school-based programs in particular has been due, in part, to their modest cost. As noted by Wang, et al., (2000) their evaluation of a school-based sexually transmitted disease screening program, published in 2000 might have been the first cost-effectiveness analysis of a school-based program. Up to 2000, no cost-effectiveness analysis was done on multiple levels of intervention, such as no intervention, intervention without emphasising the transformation of gender relations to promote gender equity, intervention with emphasis on transforming gender relations to promote gender equity or no intervention, intervention with primary target population, and intervention with primary and secondary target populations.

Relatively little is known about what types of intervention on adolescent reproductive health offer the biggest health benefits for their cost. This is seen as a barrier to policy and intervention providers (Rush et al., 2004). For instance, economic evaluations by Wang, et al. (2002) and Ateka and Lairson (2008) produced only comparisons between with and without school-based STDs screening programs and HIV/STD education intervention scenarios, respectively.

No evidence was found on economic evaluation of adolescent reproductive health education interventions in Vietnam. This therefore provided the impetus to conduct a study in Vietnam to identify a package of cost-effective strategies from the initial adolescent reproductive health education interventions. Recent international literature is reviewed in the next chapter, followed by an economic analysis of a program in Vietnam.

3.7. Summary

Economic evaluation is increasingly used in healthcare decision making to inform the efficient allocation of scarce health care resources. The four major types of economic evaluations: cost-benefit analysis, cost-effectiveness analysis, cost-utility analysis and cost-minimisation analysis, are differentiated mainly due to the methods used to measure and value the consequences of an intervention.

Two main methods are used for an economic evaluation: collecting cost and consequence data alongside an RCT or using the decision analytical modelling technique. These two ways of conducting economic evaluations have their own limitations and advantages. There has been a long history of debate over the applications of each method. However, the literature shows that there is considerable overlap or correlation between modelling and trial methods within economic evaluations. For instance, models are typically used where the clinical trials measure intermediate endpoints or have only short-term follow-up, statistical models are then used to extrapolate beyond the trial to final endpoints such as survival.

Several economic evaluations have been conducted on reproductive health interventions. However, the diversity of study settings, types of intervention, methods of economic evaluation, perspectives, methods involved in measuring costs and consequences makes it difficult to compare the findings from the studies.

Chapter 4 - Existing cost-effectiveness evidence

A review of the literature using reproducible methods was conducted to obtain and review all published cost-effectiveness analyses of behavioural intervention (health promotion intervention) targeting reproductive health of adolescents. The purpose was to assess the current evidence base for the cost-effectiveness of behavioural interventions and to compare the relative value of those interventions. The chapter starts by outlining the methods used for the review (4.1). The economic evaluation methods used (4.2), characteristics (4.3) and quality (4.4) of retrieved cost-effectiveness studies are then described. Based on this evidence, key summarised points and current limitations for decision-makers in Vietnam are presented (4.5).

4.1. Methods for the review of existing economic evaluations

4.1.1. Criteria for considering studies for review

The eligible criteria are outlined in the following table.

Table 2: Eligibility criteria used to select relevant cost-effectiveness evaluations

Inclusion criteria: - Published between 2000 – December, 2013 - Economic evaluation of education or behavioural intervention for reproductive health of adolescents - Evaluation based on decision-model - Assessment of adolescent population - Language is English - Accessible in full
Exclusion criteria: - Partial economic evaluations (cost or effectiveness study) - No comparator - Intervention other than reproductive health issues - Clinical treatment or screening other than educational or behavioural intervention

The review included cost-effectiveness analyses, which were comparative analyses of both costs and effects of at least two competing interventions, published in English, between 2000 and December, 2013. Those interventions aimed at changing knowledge, skills and attitudes of individuals, therefore, termed behavioural, not structural interventions, regarding reproductive health problems of adolescents (aged between 10 and 19 years). The outcomes of interest included: unwanted pregnancy, abortion, STDs (including HIV/AIDS, chlamydia, gonorrhea, and pelvic inflammatory diseases). All studies with the measure of health effect in quality-adjusted life-years (QALY), disability-adjusted life-years (DALY), number of cases avoided or in monetary terms saved were included.

4.1.2. Database for searching

The following electronic bibliographic databases were used to search for study:

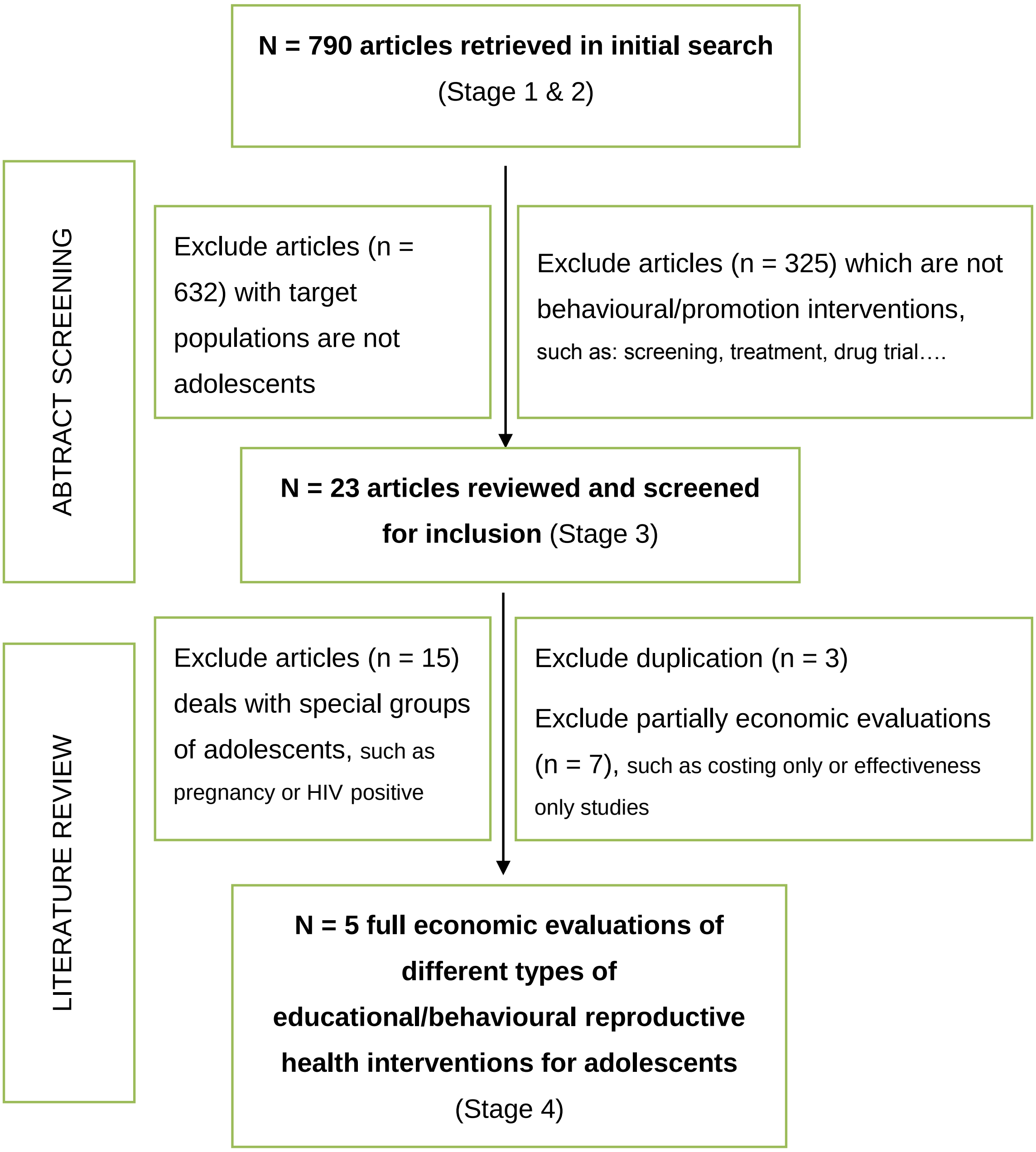
- Economic Evaluations Database (via Cochrane Library)
- Health Technology Assessment Database (via Cochrane Library)
- National Center for Biotechnology Information (PubMed)
- Medline
- Academic Search Elite
- Psychinfo or Psychnet
- Web of Science

Studies were also identified by searching databases for international health/development organisations such as the World Health Organization, the World Bank, and the U.S. Agency for International Development, US Centres for Disease Control and Prevention, etc.

Titles and (where available) abstracts of references identified by the search strategy (Appendix 1) were assessed for potential eligibility against the inclusion and exclusion criteria mentioned above. Full papers of those which appeared relevant upon title or abstract were retrieved and carefully screened. The quality of these economic evaluations was assessed using a standard checklist adapted from Drummond (2005).

Studies were selected in a four-stage process, illustrated in Figure 6.

Figure 6: Review process of articles retrieved in the literature



4.2. Description of cost-effectiveness evidence of reproductive health education intervention among adolescents

The characteristics of the remaining five economic evaluation studies as well as the interventions on which the economic evaluations were undertaken are summarised in Appendix 2. Of the 5 included studies, two (Ateka & Lairson, 2008; Pinkerton, Holtgrave, & Jemmott III, 2000) evaluated the effects of interventions targeting HIV only. One study (K. Cooper et al., 2012) evaluated the effects of different interventions focusing on STIs in general, including chlamydia, gonorrhea, HIV and genital warts. One study (Rosenthal et al., 2009) evaluated the effects of interventions focusing on unwanted pregnancies only and one study (L.Y. Wang et al., 2000) evaluated the effects of interventions focusing on both STIs and unwanted pregnancies among female adolescents.

Among these studies, four examined the cost-effectiveness of school-based interventions and one (Rosenthal et al., 2009) examined the cost-effectiveness of community-based interventions. The studies varied in terms of the characteristics of the participants. In terms of sexuality, one study (Pinkerton et al., 2000) included only African-American male adolescents; while the other four studies included both boys and girls. Ages varied as well, from at the age of 11 years (Rosenthal et al., 2009), ninth-grade students (L.Y. Wang et al., 2000) or with the mean age of 15 years old (K. Cooper et al., 2012), 15.4 years old (standard deviation of 1.3 years) (Ateka & Lairson, 2008). In terms of ethnicity/race, one study (Pinkerton et al., 2000) included African-American young people.

The duration of the interventions varied from one day to seven years. The interventions were mostly theory-based and had multi-components. The interventions were intended to increase participant's knowledge of HIV/AIDS (including correct condom use), reduce unsafe sex and unwanted pregnancies and improve the quality of sexual relationships. The interventions' effects were associated with favourable changes in the number of partners, or frequency of condom use.

One of the studies (K. Cooper et al., 2012) was conducted in the United Kingdom and the remaining studies in the United States. Standard techniques of cost-utility analysis were employed in three studies (Ateka & Lairson, 2008; K. Cooper et al., 2012; Pinkerton et al., 2000) and a cost-effectiveness analysis using a monetary net benefit approach was employed in two studies (Rosenthal et al., 2009; L.Y. Wang et al., 2000).

In all studies, the perspective of the analysis was explicitly stated. In three of the studies, the perspective was "societal", whereas in the remaining, it was the "UK National Health Service and Personal Social Services" (K. Cooper et al., 2012), and "third-party payer – Houston Housing Authority" (Ateka & Lairson, 2008) with the explanation of using data for costing components from these two organisations only.

The time horizon for three studies was one year, whereas in one study (Ateka & Lairson, 2008), it was life-time and the remaining study (Rosenthal et al., 2009), the program cost-effectiveness was estimated up to age 30 years from a group of 11 years of age intervention participants at enrolment.

All studies clearly defined the study question and explained the competing alternatives carefully. They each described the intervention and targeted participants clearly. Wang and colleagues (2000) assessed a school-based education program "Safer Choices", which was designed to prevent HIV, other STDs, and pregnancy among high school students. Safer Choices was a 2-year, theory-based, multi-component intervention. The primary aim was to reduce the number of students engaging in unprotected sexual intercourse by reducing the number of sexually active high school students and by increasing condom and contraceptive use among those who had sex. The program focused on school-wide changes to influence student behaviour, including 10 schools in northern California and 10 schools in southeast Texas, five of the schools in each state were randomly assigned to the intervention; the remaining schools were assigned to a comparison program consisting of a standard, information-based, HIV prevention curriculum.

Pinkerton and colleagues (2000) evaluated an RCT of an intensive one-day sexual risk-reduction intervention for African-American males. The intervention was designed to increase knowledge of HIV/AIDS (including correct condom use) and reduce risky sexual behaviours. The intervention used videotapes, games, exercises and other culturally and developmentally appropriate materials to convey information in an engaging and entertaining manner. Intervention participants also role-played in various sexual negotiation situations depicting potential problems in enacting safer behaviour (including abstinence). Participants in the control group attended a careers opportunities workshop.

Ateka and colleagues (2008) examined the city of Houston HIV/STD Prevention program, a school-based HIV/STD knowledge and sexual behaviour of public high school students. Participants in the program learned about HIV/AIDS, other sexually transmitted diseases, and safer sexual practices such as condom use. The expected outcome was to positively influence participants' sexual behaviour. Participants in the control group attended regular health classes, which covered HIV/AIDS and STDs.

Rosenthal and colleagues (2009) analysed a comprehensive neighborhood-based program to prevent unintended pregnancies and promote positive youth development for middle school and high school students. Six integrated components were provided to boys and girls: (1) education about family life, sex, and health; (2) academic support, including tutoring and weekly monitoring of progress; (3) career and vocational preparation; (4) artistic expression; (5) recreation; (6) physical and mental healthcare referrals. Students generally enrolled at 11 years of age and participated daily until high school graduation, with infrequent contact thereafter.

Cooper and colleagues (2012) examined two types of school-based behavioural interventions: teacher-led and peer-led. The teacher-led intervention was comprised of twenty sessions taking place over a 2-year period. The intervention was intended to reduce unsafe sex and unwanted pregnancies and improve the quality of sexual relationships. Active learning methods, such as small group work and games, information leaflets on sexual health, and development of skills, primarily through interactive video and role-playing were adopted. The peer-led intervention was comprised of three sessions led by peer educators, each lasting one hour, over one school term. The sessions covered relationships, sexually transmitted infections, use of condoms and contraception using small group work, role-plays, and informally demonstrated condom use skills. The comparator for both of these interventions was standard sexual health education, which was generally provided by teachers in British schools as part of the Special Religious Education curriculum. Standard sexual health education generally provided basic information on STIs and sexual health, but did not necessarily teach safer sex negotiation skills.

4.3. Methods used to estimate cost-effectiveness of reproductive health education interventions among adolescents

The methods used for these economic evaluation studies are summarised in Appendix 3.

Estimation of costs

Each of the studies estimated the intervention costs and medical costs averted by reducing reproductive ill-health outcomes. Regarding the intervention cost, all studies calculated the direct costs but not in-direct costs. Wang and colleagues (2000) estimated the intervention costs, which consisted of program costs and the costs of condoms and oral contraceptives, using a retrospective cost analysis. All costs were in 1994 dollars. However, the costs of developing the program and conducting the evaluation, “sunk-costs”, were excluded from the calculation. The total intervention cost was $105,243 or approximately $26 per participant. Pinkerton and colleagues (2000) estimated intervention costs retrospectively and adjusted for inflation to 1997 US dollars using the US federal government’s consumer price index, including personnel, transportation, material, and facilities costs, and incentives for participants. This was a small-scale intervention with the total intervention cost of $7,548 or approximately $89 per participant. Ateka and colleagues (2008) estimated only the direct cost of the program, including personnel, reimbursement of the community-based organisations (CBOs) that implemented the program, office space, supplies, transport, and equipment. The overall program cost was estimated by increasing the direct cost by a 30% overhead cost rate. Over the five studies, the overhead cost was only included in that study. All costs were based on 2005 expenditures, obviating the necessity for inflation adjustment. The direct intervention cost was $352,057; the overhead cost was $105,617 and total program cost was $457,674 or approximately $1.66 per participant, to deliver. Rosenthal and colleagues (2009) calculated the average annual operating costs of the program over 7 years (from 1997 to 2003), which included salaries and benefits for administrative and program staff, rent and utilities, maintenance, food, expenses for fundraising activities, the establishment and maintenance of the onsite work experience and training programs, and other miscellaneous costs. Revenue generated from fundraisers was treated as an offset to program operating costs. All costs were adjusted for inflation and stated in December 2006 dollars. The result showed that from 1997 to 2003, the total inflation-adjusted program operating costs averaged $469,304.01 per year, or $3,285,128.08 for 7 years, for a cost per student per year of $9,386.08 and a 7-year total cost per student of $65,702.56. Cooper and colleagues (2012) estimated the costs of teacher-led and peer-led sexual education interventions based upon the resources used in the SHARE and RIPPLE trials. However, limited data were available from both teams, so most of the resources were estimated by systematically extracting data from the study publications, without any inflation adjustment statement. For the teacher-led education intervention, the total cost was €108,193 or approximately €5.16 per pupil who received the program per year. For the peer-led education intervention, the total costs were estimated to be €73,154 or €18 per pupil per year.

The medical cost averted by the intervention was also estimated in each study. Most of the studies calculated the medical cost averted by preventing HIV, other STDs, and pregnancies as the number of cases averted multiplied by the medical cost per case.

For medical cost per case, three of the studies examined the cost of a single health outcome. Pinkerton and colleagues (2000) and Ateka and colleagues (2008) included only the life-time cost of HIV-related medical treatment in accordance with the standard of care recommended by an international panel, not the social cost. Those two studies used the same source for calculating the medical cost averted. The lifetime cost of HIV treatment was estimated from literature and discounted at 3%. It was estimated to be $195,188 per case. In contrast to the remaining studies, Rosenthal and colleagues (2009) assessed only the societal costs of teenage childbearing that were averted by delaying childbearing from age 18 years until age 20 or 21 years, previously published in the literature. The result showed that the societal costs were estimated to be $15,978.32 per teenage mother per year, $52,297.84 during program years; and using the extrapolation analysis, $81,256.15 in societal costs was averted by averting 1.35 teenage births for 3.76 years.

In contrast, two of the studies examined the cost of multi health outcomes. Wang and colleagues (2000) estimated both the medical and social costs per case for HIV treatment, chlamydia and gonorrhea treatments as well as the medical cost and social cost per case of PID and per live birth from the private sector perspective. Costs from the public sector perspective were subsequently calculated based on some assumptions. All data for cost calculation were gathered from published literature, and then adjusted to 1994 dollars. The total medical cost averted was $139,806 and the total social cost averted was $139,713. The study of Cooper and colleagues (2012) was different from other studies as it used UK specific resource use and costing data where available. The data were obtained from several primary and secondary sources. Unit costs for the complications of STIs, cost of HIV treatment, the first year cost of cervical cancer (as individuals infected with human papillomavirus types 16 and 18 are at risk of cervical cancer) and cost for treating genital warts were included in the calculation.

The cost items and data source for cost calculation were clearly described in all studies. When data for cost calculation was limited or unavailable, all the assumptions were stated in detail. Moreover, the inflation adjustment was mentioned in four out of five studies, except for the paper by Cooper and colleagues (2012). With future medical or social costs averted, the discount rate was applied in all studies. Therefore, the findings of the costing component in each study appear to be credible.

Estimation of outcomes of the interventions

In order to measure the effects of the interventions, four studies clearly stated the time horizon of 1 year; only one study (Rosenthal et al., 2009) had a longer horizon of 7 years, the same as the intervention duration. Four of the studies (Ateka & Lairson, 2008; K. Cooper et al., 2012; Pinkerton et al., 2000; L.Y. Wang et al., 2000) included the effect of changes in sexual behaviour in terms of HIV infection averted, and all of these studies examined not only the primary transmission of HIV but also the secondary transmission. For the primary transmission, each study adapted a previously developed Bernoulli statistical model because it estimated the effect of changes in sexual behaviour in terms of STIs averted. The Bernoulli model of HIV transmission is a cumulative probability equation that describes the probability of HIV infection based upon HIV prevalence (π), single act transmission probability (α), condom effectiveness (e) and condom use (f), number of sexual episodes (n), and number of sexual partners (m). For example, the estimated probability of an uninfected person becoming infected is P,

$$P = 1 – [(1 − \pi) + \pi \,|1 − \alpha(1 − ef)|^{n}]^{m}$$

The model estimates the probability of becoming infected for the intervention and comparator groups according to changes in parameters that may be in response to the intervention, such as condom use, number of sexual partners, and number of sexual episodes. The number of cases averted was estimated by multiplying the results by the number of people who received the intervention. The assumption being that cases averted would in turn infected further individuals through secondary transmission. Cooper and colleagues (2012) estimated the number of cases averted through secondary transmission by multiplying the risk of becoming infected by the number of cases averted through primary transmission. Other studies (Ateka & Lairson, 2008; Pinkerton et al., 2000; L.Y. Wang et al., 2000) adopted a different statistical model to estimate the probability of secondary transmission within 1 year:

$$P'=1− [1− \alpha(1−ef)]^{n}$$

The studies used a range of values for the input parameters. Wang and colleagues (2000) used an average HIV point prevalence of 0.002 in their calculation. Pinkerton and colleagues (2000) used the same HIV point prevalence among males and females in the community of 0.6% in their outcome estimation. Ateka and colleagues (2008) used an unadjusted HIV prevalence of 0.006 and an ethnicity-adjusted HIV prevalence of 0.054203 in their effect estimations. Cooper and colleagues (2012) used a wide range of HIV point prevalence, between 0.06% and 0.12% for female adolescents, and between 0.13% and 0.26% for male adolescents.

In addition to HIV infections, two studies included the effect of changes in sexual behaviour in terms of other STI infections averted. Wang and colleagues (2000) and Cooper and colleagues (2012) used the equations presented to estimate the cases of other STI infections avoided, i.e. chlamydia, gonorrhea and pelvic inflammatory disease. The studies used a range of values for the input parameters. Wang and colleagues (2000) used an average Chlamydia incidence rate of 0.078 and an average gonorrhea incidence rate of 0.006 in their calculation. Cooper and colleagues (2012) used a relatively wide range of other STIs point prevalence, of between 0.16% and 12% for female adolescents and between 0.03% and 1.5% for male adolescents.

Wang and colleagues (2000) also developed a pregnancy model in which contraceptive use was used to estimate cases of pregnancy averted. They used multiple health outcome measures, and different statistical models were applied to estimate the effects of the intervention. The results from Wang and colleagues (2000) showed that for a cohort of 275,000 students, the number of pregnancy cases averted was 18.5. Rosenthal and colleagues (2009) examined a single health outcome only, the unwanted pregnancy. They developed a model to calculate the race/ethnicity-specific probability of teenage childbearing between the age of 11 and high school graduation. It found that the teenage childbearing rate was reduced from 94.10 to 40.00 per 1000 teenage girls with the intervention. The results from Cooper and colleagues' study (2012) showed that for a cohort of 1000 girls aged 15 years, the number of pregnancy cases was 0.05 cases lower than that of standard sex education.

Estimation of effectiveness

Three of the studies (Ateka & Lairson, 2008; K. Cooper et al., 2012; Pinkerton et al., 2000) used the same unit of effectiveness as quality-adjusted life-years (QALYs) because they adopted the cost-utility analysis approach. The remaining studies (Rosenthal et al., 2009; L.Y. Wang et al., 2000) utilised cost-effectiveness analysis using a monetary net benefit approach; hence, they used monetary terms to report the effectiveness.

Pinkerton and colleagues (2000) estimated that the intervention averted 0.8% of an infection, which translated to a savings of one tenth of a QALY (approximately 0.8% x 13.98) over the assumed one year duration. Ateka and colleagues (2008) reported the number of QALYs saved for each averted HIV infection was 28.2, 18.6, and 14.7 for discount rates of 0%, 3%, and 5%, respectively. Cooper and colleagues (2012) calculated for a cohort of 1000 boys and 1000 girls aged 15 years, two STI cases would be averted and 0.35 QALYs would be saved by the intervention.

Wang and colleagues (2000) applied cost-effectiveness analysis using a monetary net benefit approach. An estimated 0.12 cases of HIV, 24.37 cases of chlamydia, 2.77 cases of gonorrhea, 5.86 cases of pelvic inflammatory disease, and 18.5 pregnancies were prevented by the intervention. Subsequently, the total costs averted by the intervention was $279, 519, including the medical cost of $139,806 and the social cost of $139,713. Rosenthal and colleagues (2009) also reported a total societal cost of $52,297.84 was averted by the intervention.

Cost-effectiveness ratio computation

Three of the studies (Ateka & Lairson, 2008; K. Cooper et al., 2012; Pinkerton et al., 2000) computed the cost−utility ratio. The remaining studies (Rosenthal et al., 2009; L.Y. Wang et al., 2000) calculated the net benefit or the cost-benefit ratio. In order to calculated the cost−utility ratio, Pinkerton (2000), Ateka (2008), Cooper and colleagues (2012) based on the estimated number of averted infections (A) and program cost (C), and the following equation:

$$R = (C - AT)/AQ.$$

Where T is the lifetime treatment cost of HIV infection and Q is the number of quality-adjusted life years (QALYs) saved for each averted infection. Pinkerton and colleagues (2000) reported the cost-utility ratio of approximately $57,000 U.S. per QALY saved when training costs were included, and US$41,000 per QALY saved when they were excluded. Ateka and colleagues (2008) concluded the base-case cost-utility ratio of $32,755 per QALY saved for males and $292,046 per QALY saved for females. Cooper and colleagues (2012) reported that compared to standard education, the incremental cost-effectiveness of the teacher-led and peer-led interventions was €24,268 and €96,938 per QALY gained, respectively.

In contrast, Wang (2000), Rosenthal and colleagues (2009) calculated the net benefit of the intervention using the following equation:

$$\text{Net Benefit}_{intervention} = (C_{averted} + B_{intervention}) - C_{intervention}$$

Where $C_{averted}$ is the societal costs averted among participants of the intervention, $B_{intervention}$ is the economic value of intervention participation and $C_{intervention}$ is the total intervention operating costs. Wang and colleagues (2000) reported the intervention net benefit of $174,276. Rosenthal and colleagues (2009) showed the net benefit of $559,677.05 for the whole intervention, or $1599.08 per adolescent per year. In their extrapolation analysis, benefits to society exceed costs by $10,474.77 per adolescent per year by age 30 on average.

Moreover, Wang and colleagues (2000) calculated the cost-effectiveness ratio by taking the total costs averted divided by the intervention operating costs. They reported for every dollar invested in the program, $2.65 in total medical and social costs were saved.

Cost-effectiveness threshold

Two of the studies (Rosenthal et al., 2009; L.Y. Wang et al., 2000) involved the cost effectiveness analysis using a monetary net benefit approach, therefore, as long as the net benefit of the intervention exceeded 0, the intervention could be considered to be cost-effective. The other studies adopted the cost utility analysis approach, the cost-utility ratio needed to be compared with a cost-utility threshold. Those studies used different thresholds for their conclusion. In Pinkerton's study (2000), a health related program with cost utility ratios that were less than $40,000 to $60,000 per QALY saved are generally considered cost-effective, whereas those whose CUEs exceed $180,000/QALY were of questionable cost-effectiveness in comparison with other health related expenditures. Ateka and colleagues (2008) used the conventional threshold of considering health service programs, with cost−utility-ratios between $30,000 and $140,000 per QALY saved considered to be cost-effective. Cooper and colleagues (2012) completed the evaluation under the perspective of the UK National Health Service and Personal Social Services, where the threshold for a cost-effective intervention of less than £30,000 (€36,000) per QALY was adopted.

Sensitivity analysis

Sensitivity analysis technique was used in all of the studies. Wang (2000) and Cooper (2012) and colleagues tested the robustness of the base-case results by conducting a multivariable sensitivity analysis over a reasonable range of six and eleven variable estimates, respectively. The suitable range of the variables was clearly described in each study. The results of the sensitivity analysis in Wang's study (2000) demonstrated that changes in major model variables influenced health and economic benefits. Although the results of most scenarios were found to save costs, the results were not cost saving in two scenarios. To determine the robustness of findings, Rosenthal and colleagues (2009) implemented sensitivity analyses to examine the time horizon for which the total social costs and benefits of the program were equivalent. For the current in-time intervention analysis, key variables were varied (number of students, proportion female, expected pregnancy rates for nonparticipants and participants, average age of childbearing, annual program costs, and discount rate for future benefits) over a reasonable range to determine at which point the program's economic benefit exceeded the program costs. Pinkerton (2000), Ateka and colleagues (2008) conducted the sensitivity analyses on the discount rate to assess how uncertainty in this parameter affected the main result (discount rate at 0%, 3%, 5%).

Comparison of results

A comparison of the studies showed a wide range of cost-effectiveness estimates depending upon the assumptions and parameter values used. Cooper and colleagues (2012) showed uncertainty around the results due to the limited effect of the intervention on behavioural outcomes and paucity of data for other input parameters. Pinkerton and colleagues (2000) showed that the HIV prevention intervention was moderately cost-effective in comparison to other health care programs. Rosenthal and colleagues (2009) made a conclusion regarding the cost-effectiveness of the intervention under a condition, participants being young adults. In contrast, Wang and colleagues (2000) concluded that the Safer Choices program was cost-effective and cost saving in most scenarios considered. Ateka and colleagues (2008) also concluded that the intervention achieved significant risk reduction in HIV infection, particularly among female participants, on a relatively low budget.

4.4. Quality assessment of cost-effectiveness evidence of reproductive health education intervention among adolescents

The quality of eligible studies was assessed using a standard checklist adapted from Drummond et al. (2005) (Table 3)

Table 3: Quality assessment of existing cost-effectiveness evidence

No.	Criteria	Cooper (2012)	Rosenthal (2009)	Ateka (2007)	Pinkerton (2000)	Wang (2000)
1.	**Was a well-defined question posed in answerable form?**	**Y**	**Y**	**Y**	**Y**	**Y**
	1.1. Did the study examine both costs and effects of the service(s) or programme(s)?	Y	Y	Y	Y	Y
	1.2. Did the study involve a comparison of alternatives?	Y	N	Y	N	Y
	1.3. Was a viewpoint for the analysis stated and was the study placed in any particular decision-making context?	Y	Y	Y	Y	Y
2.	**Was a comprehensive description of the competing alternatives given (i.e. can you tell who did what to whom, where, and how often)?**	**Y**	**N**	**Y**	**N**	**Y**
	2.1. Were there any important alternatives omitted?	N	NA	N	NA	N
	2.2. Was (should) a do-nothing alternative be considered?	Y	NA	Y	NA	N
3.	**Was the effectiveness of the programme or services established?**	**Y**	**Y**	**Y**	**Y**	**Y**
	3.1. Was this done through a randomised, controlled clinical trial? If so, did the trial protocol reflect what would happen in regular practice?	N (based on LR of RTCs))	N	N (questionnaire on behaviour)	N	Y (RCTs)
	3.2. Was effectiveness established through an overview of clinical studies?	Y	N	Y	N	N
	3.3. Were observational data or assumptions used to establish effectiveness? If so, what are the potential biases in results?	Y	Y	Y	Y	NA

No.	Criteria	Cooper (2012)	Rosenthal (2009)	Ateka (2007)	Pinkerton (2000)	Wang (2000)
4.	**Were all the important and relevant costs and consequences for each alternative identified?**	**Y**	**Y**	**Y**	**Y**	**Y**
	4.1. Was the range wide enough for the research question at hand?	Y	Y	Y	Y	Y
	4.2. Did it cover all relevant viewpoints?	Y	Y	Y	Y	Y
	4.3. Were the capital costs, as well as operating costs, included?	NA	N (operating cost only)	Y	N (operating cost only)	Y
5.	**Were costs and consequences measured accurately in appropriate physical units (e.g. hours of nursing time, lost work-days, gained life years)?**	**Y**	**Y**	**Y**	**Y**	**Y**
	5.1. Were any of the identified items omitted from measurement? If so, does this mean that they carried no weight in the subsequent analysis?	N	N	N	N	Y
	5.2. Were there any special circumstances (e.g., joint use of resources) that made measurement difficult? Were these circumstances handled appropriately?	N	N	N	N	N
6.	**Were the cost and consequences valued credibly?**	**Y**	**Y**	**Y**	**Y**	**Y**
	6.1. Were the sources of all values clearly identified? (Possible sources include market values, patient or client preferences and views, policy-makers' views and health professionals' judgments)	N	Y	Y	Y	Y
	6.2. Were market values employed for changes involving resources gained or depleted?	Y	Y	Y	Y	Y

No.	Criteria	Cooper (2012)	Rosenthal (2009)	Ateka (2007)	Pinkerton (2000)	Wang (2000)
	6.3. Where market values were absent (e.g. volunteer labour), or market values did not reflect actual values, were adjustments made to approximate market values?	NA	Y	NA	Y	NA
	6.4. Was the valuation of consequences appropriate for the question posed (i.e. has the appropriate type or types of analysis – cost-effectiveness, cost-benefit, cost-utility – been selected)?	Y	Y	Y	Y	Y
7.	**Were costs and consequences adjusted for differential timing?**	**NA**	**Y**	**Y**	**NA**	**Y**
	7.1. Were costs and consequences that occur in the future 'discounted' to their present values?	NA	Y	Y	NA	Y
	7.2. Was there any justification given for the discount rate used?	NA	Y	Y	NA	Y
8.	**Was an incremental analysis of costs and consequences of alternatives performed?**	**Y**	**NA**	**Y**	**NA**	**Y**
	8.1. Were the additional (incremental) costs generated by one alternative over another compared to the additional effects, benefits, or utilities generated?	Y	NA	Y	NA	Y
9.	**Was allowance made for uncertainty in the estimates of costs and consequences?**	**Y**	**Y**	**Y**	**Y**	**Y**
	9.1. If data on costs and consequences were stochastic (randomly determined sequence of observations), were appropriate statistical analyses performed?	NA	NA	NA	NA	Y
	9.2. If a sensitivity analysis was employed, was justification provided for the range of values (or for key study parameters)?	Y	Y	Y	Y	Y

No.	Criteria	Cooper (2012)	Rosenthal (2009)	Ateka (2007)	Pinkerton (2000)	Wang (2000)
	9.3. Were the study results sensitive to changes in the values (within the assumed range for sensitivity analysis, or within the confidence interval around the ratio of costs to consequences)?	Y	N	Y	N	N
10.	**Did the presentation and discussion of study results include all issues of concern to users?**	**Y**	**Y**	**Y**	**Y**	**Y**
	10.1. Were the conclusions of the analysis based on some overall index or ratio of costs to consequences (e.g. cost-effectiveness ratio)? If so, was the index interpreted intelligently or in a mechanistic fashion?	Y	N	Y	N	Y
	10.2. Were the results compared with those of others who have investigated the same question? If so, were allowances made for potential differences in study methodology?	Y	NA	Y	NA	Y
	10.3. Did the study discuss the generalizability of the results to other settings and patient/client groups?	NA	NA	NA	Y	Y
	10.4. Did the study allude to, or take account of, other important factors in the choice or decision under consideration (e.g. distribution of costs and consequences, or relevant ethical issues)?	Y	NA	Y	Y	Y
	10.5. Did the study discuss issues of implementation, such as the feasibility of adopting the 'preferred' program given existing financial or other constraints, and whether any freed resources could be redeployed to other worthwhile programs?	N	N	Y	Y	Y

(Source: the standard checklist adapted from Drummond et al (2005))

Four of these studies addressed the prevention of HIV, but only two evaluated other STIs in addition to HIV. The studies that did not include other STIs are likely to have underestimated the potential benefits of the interventions. The remaining study addressed the prevention of unwanted pregnancy among female adolescents only.

All studies used mathematical models (either the Bernoulli model or the pregnancy model) extrapolating the changes in sexual behaviour to health outcomes of interest, i.e. the number of cases of HIV averted, the number of other STIs averted (chlamydia, gonorrhea, genital warts, pelvic inflammatory disease, etc.), or the number of unwanted pregnancies averted, or the number of pregnancy outcomes (including abortion, miscarriage, live births) averted.

From the literature, it can be seen that the evaluation in general and economic evaluation in particular of health promotion and health education interventions presents remarkable methodological challenges compared with the evaluation of clinical interventions. Decision-makers often prefer evidence comparing relevant alternatives to come from randomised controlled trials (RCTs) where available. However, there are fewer controlled trials of public health interventions, and these tend to be heterogeneous, of variable methodological quality, and have short follow-up.

Economic evaluation should ideally include estimation of long-term outcomes, with health outcomes typically measured in QALYs. Unfortunately, they are often difficult to quantify within a public health context. Public health interventions are often wide ranging with the cost and benefits associated with an intervention falling in many parts of the public sector (e.g. education and health services).

Finally, data used to build economic models are often scarce and several assumptions may have to be made. A range of assumptions and parameter values were used in the mathematical models and this led to substantial differences in the estimated cost-effectiveness of the behavioural interventions. Because sexual behaviour has not shown a statistically significant intervention effect, the findings presented so far should be treated with caution and only regarded as illustrative.

4.5. Summary and limitations of the existing literature for Vietnamese decision-makers

The review of cost-effectiveness studies identified only five economic evaluations of behavioural interventions for the prevention of unintended pregnancies and STIs in adolescents. Those analyses are very useful but have major limitations for Vietnamese decision-makers, such as intervention-providers, sponsors and local stakeholders (i.e. Vietnam Ministry of Health, Vietnam Ministry of Education and Training). None are based on developing country cost norms.

Regarding gender issues, in one of included studies (Ateka & Lairson, 2008), the findings revealed gender differences in the degree to which participants benefited. The intervention was cost-saving for female participants and cost-effective for male participants when using the ethnicity adjusted HIV prevalence with the assumption of best case scenario. However, the intervention remained cost-effective for female but not male participants in the base case scenario. Therefore, it suggested the importance of gender issues within adolescent reproductive health and the need for implementing different interventions targeting different groups of adolescents. Subsequently, more economic evaluations should be done in order to be certain as to which type of intervention is more cost-effective for each group.

All included analyses were published between 2000 and 2012. With the exception of one study in the United Kingdom, all studies were conducted in the United States. As a consequence, there is a need for economic evaluation on reproductive health behavioural intervention among adolescents in developing countries.

Chapter 5 - Methods: A decision analytic model to evaluate the cost-effectiveness of the interventions

This chapter describes the methods used to evaluate the cost-effectiveness of the three competing interventions in addressing reproductive health problems among adolescents in Chi Linh, Vietnam. The overall approach to the evaluation is defined (5.1), followed by a description of the development of the economic decision model (5.2), and data sources for the input parameters (5.3). The methods used to analyse the cost–effectiveness of different levels of education interventions (5.4) are then outlined. A summary of the overall evaluation process concludes the chapter (5.5).

5.1. Overall approach to the evaluation

5.1.1. Choice of decision context

This economic evaluation was done in order to assist intervention implementers, sponsors and local stakeholders to identify which type of reproductive health intervention is cost-effective in a Vietnamese context, as well as whether an expansion of the reproductive health education intervention to other areas should be considered. Therefore, the context for this evaluation was the intervention-provider team, sponsors and local stakeholders (such as Vietnam Ministry of Health, Vietnam Ministry of Education and Training).

5.1.2. Choice of study perspective

As suggested by Torrance (1986), the societal viewpoint is the appropriate one for public policy decision making. A societal perspective was adopted for this economic evaluation. This study included the perspective of: the intervention provider, the primary target population, who were adolescents; and the secondary target population, who were the adolescents' parents.

5.1.3. Choice of modelling technique

This cost-effectiveness analysis relied on the principles of the Markov model, distinguished by three concepts. First, conditions in the model are comprised of eleven mutually exclusive health states. Second, Markov models assume that time is broken into discrete intervals or cycles of 3 months each. Third, events are modelled as transitions between states, with these transitions occurring only once at the end of each cycle.

5.1.4. Choice of unit for effectiveness measurement

Both QALYs and DALYs are used to express the effectiveness of health care as a combination of a change both in the length and quality of life. However, literature shows that QALYs are considered the most widely used and recommended method for capturing both quality and quantity of life. Therefore, QALYs were used as a measure of effectiveness in this study.

5.1.5. Choice of method for valuing "quality weight" for QALYs

In order to obtain a preference based valuation of each health state in the model for the calculation of QALYs later on, the indirect measurement approach was used in this study. This approach involved the use of generic utility instruments; multidimensional HRQL questionnaires developed using multi-attribute utility theory (MAUT). There are some common generic utility instruments, including the EuroQoL five dimensions (EQ-5D). To date, there are more than 150 official language versions of EQ-5D questionnaire, including Vietnamese. As health conditions of interest in this study were all sensitive and it was sometimes difficult to access "current patients", "hypothetical patients" were recruited.

5.1.6. Reference year and time horizon

The reference year was 2011, the year in which the reproductive health education intervention for adolescents in Chi Linh was delivered.

In this analysis, the time horizon for tracking intervention cost was two years. Although the bigger project, on which this economic evaluation was based, was implemented over three phases, the costs incurred in phase one and phase three were excluded. In other words, intervention cost data was collected during the 12-month period of preparation and the 12-month period of intervention only. Consequently, neither intervention design and development costs (which are "sunk" or non-recoverable) nor research and pre and post evaluation costs were included.

Moreover, the time horizon for modelling intervention consequences as well as associated health care costs was 14 years for male students and 10 years for female students. This time horizon length was chosen for several reasons. First, it was assumed that the education intervention delivered in Chi Linh would improve reproductive health knowledge and attitudes among adolescents, which would in turn reduce risky behaviours and improve reproductive health over their life-times. However, as the Population and Family Planning Change survey conducted in

Vietnam found the mean age of marriage was 22.8 years for females, and 26.6 years for males (General Statistics Office, 2009; World Health Organization, 2010), it was assumed that after getting married, the population would have different sexual patterns, as well as probabilities of acquiring and transferring reproductive health related diseases, which would affect the model remarkably. In other words, it would not be captured properly using this model. Second, almost all states in the model are acute except for HIV infection, which is a chronic condition. Some previous economic evaluations of HIV prevention assumed that the length of time from HIV infection to death was 12 years (Guinan et al., 1994). Due to the reasons mentioned above, the model was evaluated over a time horizon of 14 years for male students and 10 years for female students only (until marriage).

5.1.7. Target population

Intervention cost calculation involved the actual adolescents as the primary target participants of the reproductive health education intervention. In order for the Markov model to estimate the change in both costs and outcomes, a notional population of 100,000 students was required, divided equally into two groups of male and female students as a starting point.

5.1.8. Discounting

Discounting is a standard practice in economic evaluation to incorporate time preferences for current and future costs and benefits. In this study, discounting was applied to both costs and benefits (QALYs). The choice of discount rate was 3% per annum, equivalent to a quarterly discounting rate of 0.74%.

The formula for discounting as following:

$$\boldsymbol{PV} = \frac{\boldsymbol{FV}}{(\mathbf{1}+\boldsymbol{r})^{\boldsymbol{t}}}$$

With ***PV***: discounted value, present value, ***FV***: future value,

r: discount rate, ***t***: number of discount periods

5.1.9. Definition of competing alternatives

The intervention was based on the Chililab DESS in seven communes/towns of Chi Linh district as mentioned in Chapter 1. These seven communes/towns of Chililab DESS were divided into three sites (A, B and C). Site A included one town and two communes which served as controls and did not receive any interventions, labelled “current practice”. Site B included one town and one commune, and received school-based and health facility –based components, **without** emphasis on transforming of gender relations to promote gender equity. Site C included one town and one commune, and received school-based, community-based and health facility-based components, **with** emphasis on the transformation of gender relations to promote gender equity.

Therefore, this economic evaluation included all three competing alternatives; interventions at levels A, B and C.

5.2. Development of economic model

5.2.1. Validation of the economic decision model

The model drafts were shown to two highly-experienced reproductive health clinicians, three designers and the implementers of the interventions, lecturers at Hanoi School of Public Health, to make sure that the model structure could capture the effect of the intervention on both costs and health benefits. Comments and feedback were taken into account, then the literature was reviewed once more regarding some key questions and the final model was refined accordingly.

5.2.2. Structure of the economic decision model

The decision model was designed to predict costs and health outcomes of different levels of reproductive health education from a societal perspective. The model was based on the natural history of reproductive health related diseases. The model was used to show how a hypothetical cohort of adolescents moves between different health states over time. The model begins at the year of the intervention commenced, 2011, and continues in 3-month increments. The model simulation ends when all adolescents in the cohort are in a “deceased state” or reach 27 years of age for male adolescents and 23 years of age for female adolescents (as per time horizon information in 5.1.6).

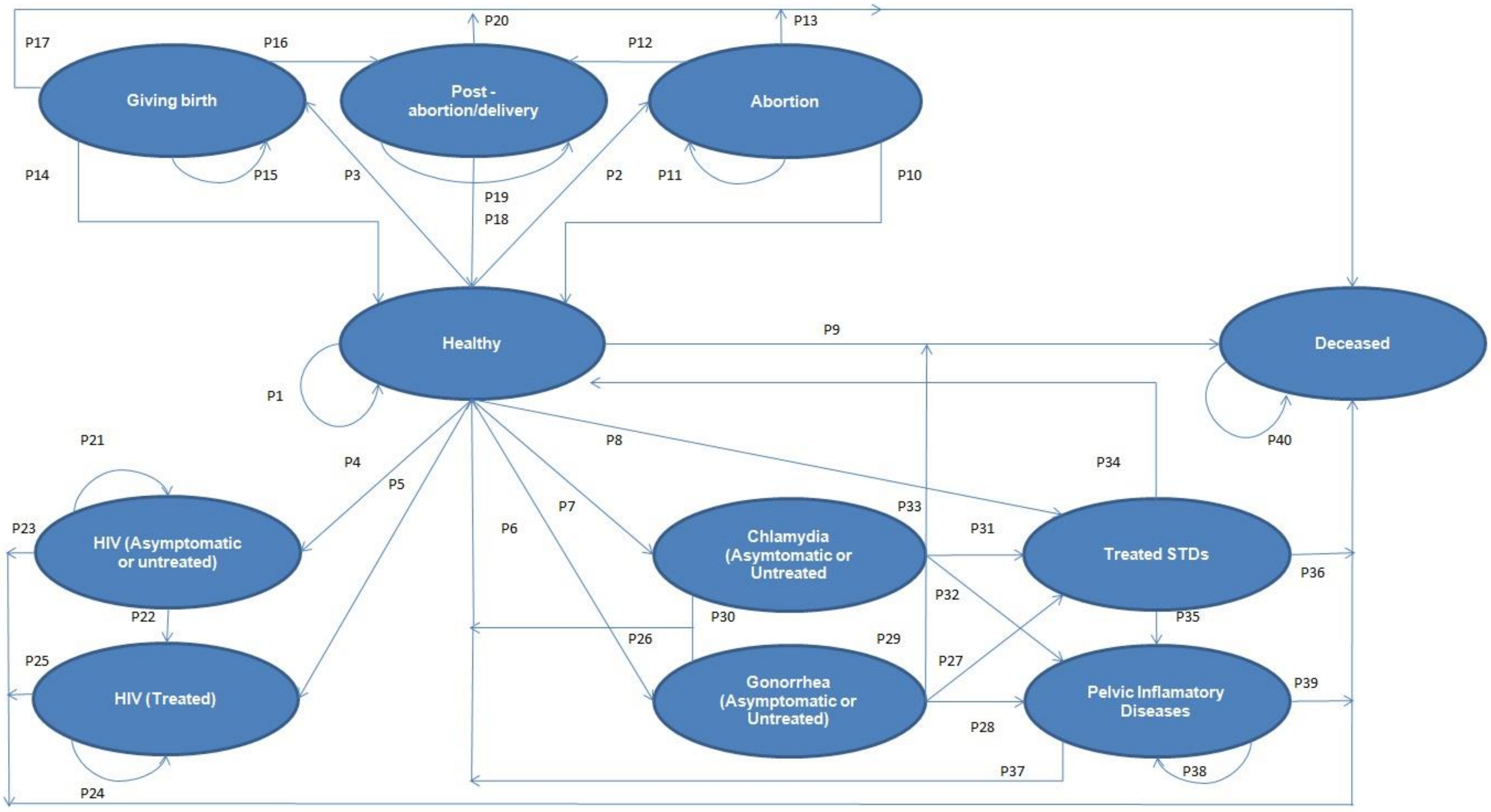
In order to define a model structure and determine transition probabilities that could appropriately and feasibly predict the effectiveness of interventions, it was important to systematically review the available epidemiological data, and to describe the natural history of the diseases related to reproductive health issues. It was not feasible to capture all possible health states found in the real world in models due to financial and time constraints. Therefore, the Markov model in this study included only 11 different health states related to reproductive ill-health. They were: healthy, abortion, giving birth, post-abortion/delivery, HIV infected but asymptomatic or untreated, HIV infected and treated, other STDs infected but asymptomatic or untreated (in this study, the category “other STDs” consists of chlamydia and gonorrhea infections), other STDs infected and treated, PID infected or deceased. The structure of the model is shown in Figure 7. Each state represents a mutually exclusive health state and, as such, is associated with a particular set of health and/or economic outcomes.

The model is started with all healthy male or female adolescents at intervention level A, B or C. Adolescents can only remain in the same state (represented by the circular arrow) or progress through the model. Adolescents, both male and female, face an underlying risk of mortality in all states in the model that reflects the risk posed by that health state. The underlying risk of mortality varies based on the age of adolescents in each cycle. Deceased is an absorbing state.

Typically, for each health state there are one or more of the following transition probabilities:

1. → Move to another health state, e.g. from healthy to diseased;
2. Remain in that health state;
3. Get better or remit to a non-diseased health state (Healthy state);
4. Die from disease (‘case-fatality’ which is defined as the risk of death due to being in a particular health state in excess of the average risk of dying in the population); and
5. Die from all other causes (‘background mortality rate’).

Figure 7: Markov model used to describe the transition to reproductive health related states of adolescents



5.2.4. Model assumptions

The model was structured identically for adolescents at intervention levels A, B and C, but those at level B and C were assigned added intervention costs and a lower probability of getting diseases related to reproductive health (under the assumption that the education intervention promoted the practice of safe reproductive health behaviours, consequently making adolescents healthier and utilising fewer health care resources for treatment of reproductive health-related diseases). Similarly, the model was structured identically for male and female adolescents at all three interventions, but set zero value to males' transition probabilities from and to several health states, such as abortion, post abortion/delivery and giving birth.

Only 5-year age group mortality rates were available from the abridged life tables produced by the WHO for Vietnam, therefore, the probability of dying by all other causes was assumed to be constant over time in each age group in order to calculate the age-specific transition probability from the state of "healthy" to "deceased".

For the translation of surrogate outcomes from the education interventions (such as increase in condom use, increase in condom use properly/correctly, decrease in number of sexual partners) into ultimate effectiveness of the interventions (for example, decreased probability of getting HIV and other STDs infection), several assumptions were made:

1. All sexual partners were of the opposite sex.
2. The sexual partners of intervention students were from a pool outside the intervention group with no overlap among sexual partners. As only approximately 79 male and 68 female students were sexually active in each intervention site, the chance of their sexual partners being in the same group was small.
3. The HIV point prevalence and STDs incidence rates were equal in all age groups from 13 to the age of getting married.
4. Condom use per act was equal to the percentage of students using condoms at last intercourse.
5. HIV infected people became aware of the infection after 2 years; they would live for a total of 15 years following infection.
6. The education intervention effects would last until primary intervention participants reached marriage age in Vietnam.

5.3. Input parameters of the model

5.3.1. Overview of model parameters

The model is informed by input parameters in four major groups: transition probabilities, costs, values of health states and effectiveness. Transition probabilities are specified by gender. Costs are organised by ***intervention costs*** and ***health-care costs***, which are treatment costs for HIV infection, other STDs, PID, abortion and giving birth. Values of health states refer to the quality of life (utility scores) associated with each model health state. Effectiveness refers to the effectiveness of the education intervention. All costs and health benefits (QALYs) were discounted at 0.74% quarterly.

All input parameters used in the model are listed in Appendix 4.

5.3.2. Transition probabilities

The direction and speed of transitions between different health states are determined by transition probabilities. The transition matrices for adolescents under 3 different levels of education intervention are illustrated in Appendix 5.

Time-dependent transition probabilities were adopted to illustrate the structure of the model, which means that transition probabilities varied according to the time in the model (A. Briggs et al., 2006b) with one of the time-dependent probabilities being the all causes mortality rate. The all causes mortality rate was taken from the latest Life Table of Vietnam developed by the World Health Organization (2009), which is shown in Table 4.

For the “baseline” scenario (i.e. no intervention – level A), transition probabilities were taken from different sources, such as:

1. Pre-intervention data from primary sources, for instance, the adolescent reproductive health education intervention in Chi Linh, Vietnam or secondary database of longitudinal study on youth health in Chililab (Adolescent Reproductive Health round 1 or round 2) or routine surveillance database of the Chililab DESS
2. Data from related studies in Vietnam, such as the Survey Assessment of Vietnamese Youth, round 1 in 2003 and round 2 in 2008,
3. Results from elicitation of expert opinions, which will be described in detail in Chapter 6.

Table 4: Probability of all causes mortality for Vietnam population

Age	Annually probability of all causes death		Quarterly probability of all causes death	
	Males	Females	Males	Females
10-14	0.00226	0.00162	0.000113	0.000081
15-19	0.00568	0.00274	0.000285	0.000137
20-24	0.00762	0.0033	0.000382	0.000166
25-29	0.0075	0.00386	0.000376	0.000194

Source: Life Table of Vietnam developed by the World Health Organization (2009)

For the alternative scenarios (i.e. intervention levels B and C), as the post-intervention data from primary sources, the adolescent reproductive health education intervention in Chi Linh and the secondary database of longitudinal study on youth health in Chililab (Adolescent Reproductive Health Round 3) were not available on time, the transition probabilities were based on an adjustment to the baseline values using these techniques:

1. Estimating post-intervention transition probabilities using modelling or equation, such as using the Bernoulli-process model for the calculation of ***probability of getting HIV infection*** among adolescents who are sexually active. The Bernoulli model of HIV transmission is a cumulative probability equation that describes the probability of HIV infection based upon HIV prevalence (π), single act transmission probability (α), condom effectiveness (e) and condom use (f), number of sexual episodes (n), and number of sexual partners (m). For example, the estimated probability of an uninfected person becoming infected is P,

$$P = 1 – [(1 − \pi) + \pi\, |1 − \alpha(1 − ef\,)|^{n}]^{m}$$

The model estimates the probability of becoming infected for the intervention and comparator groups according to changes in parameters that may be affected by the intervention, that is, condom use, number of sexual partners, and number of sexual episodes. Those parameters are described in Chapter 6.

2. Estimating post-intervention transition probabilities using the equation or model developed by Wang et al. (2000) to calculate the ***probability of becoming pregnant*** within 3 months without condom use:

$$P = 1-(1-Q)^3, \text{ with } Q = q_1 \times q_2 \times q_3 \times q_4,$$

q_1: Probability that ovulation in a given month can support a pregnancy

q_2: Probability of coitus in the fertile period = 1 - [1-(2/28)]^s, (s is the number of sexual contact within 1 month)

q_3: Probability of fertilisation given coitus in the fertile period

q_4: Probability that a conception is recognised, given fertilisation occurs

The model estimates the probability of becoming infected for the intervention and comparator groups according to changes in parameters that may be affected by the intervention, that is, condom use, number of sexual partners, and number of sexual episodes. Those parameters are described in Chapter 6.

3. Eliciting and pooling the post-intervention transition probabilities from elicitation of expert opinions, which are described in detail in Chapter 6.

Results of transition probabilities for male and female groups for the “baseline” scenario (i.e. no intervention – level A) compared to “alternative” scenarios (i.e. level B and C) are shown in Table 5.

Table 5: Transition probabilities for male and female groups at intervention level A, B and C

No.	Parameter description	Male			Female		
		Level A	Level B	Level C	Level A	Level B	Level C
	Probability transition from not sexually active to sexually active	**0.02208**	**0.01926**	**0.01832**	**0.01947**	**0.01707**	**0.01578**
P1	Prob. Transition from Healthy to Healthy *(remain Healthy)*	0.99846	0.99892	0.99908	0.99629	0.99702	0.99739
P2	Prob. Transition from Healthy to Abortion	0.00000	0.00000	0.00000	0.00003	0.00002	0.00002
P3	Prob. Transition from Healthy to Giving birth	0.00000	0.00000	0.00000	0.00001	0.00001	0.00001
P4	Prob. Transition from Healthy to HIV *(Asymptomatic or untreated)*	0.0000032	0.0000022	0.0000019	0.0000077	0.0000060	0.0000050
P5	Prob. Transition from Healthy to HIV *(Treated)*	0.00000075	0.0000005	0.00000	0.0000018	0.0000014	0.00000
P6	Prob. Transition from Healthy to Gonorrhea *(Asymptomatic or Untreated)*	0.00031	0.00022	0.00018	0.00128	0.00103	0.00090
P7	Prob. Transition from Healthy to Chlamydia *(Asymptomatic or Untreated)*	0.00046	0.00032	0.00028	0.00165	0.00133	0.00116
P8	Prob. Transition from Healthy to Treated acute STDs	0.00077	0.00054	0.00046	0.00073	0.00059	0.00052
P9	Prob. Transition from Healthy to Deceased	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P10	Prob. Transition from Abortion to Healthy	0.00000	0.00000	0.00000	0.59142	0.59142	0.5914173
P11	Prob. Transition from Abortion to Abortion *(pregnancy unknown then still not yet abort)*	0.00000	0.00000	0.00000	0.00000	0.00000	0.0000000

No.	Parameter description	Male			Female		
		Level A	Level B	Level C	Level A	Level B	Level C
P12	Prob. Transition from Abortion to Post-abortion/delivery	0.00000	0.00000	0.00000	0.40835	0.40835	0.4083493
P13	Prob. Transition from Abortion to Deceased	0.00000	0.00000	0.00000	0.0002334	0.0002334	0.0002334
P14	Prob. Transition from Giving birth to Healthy	0.00000	0.00000	0.00000	0.16765	0.16765	0.1676483
P15	Prob. Transition from Giving birth to Giving birth *(opt to carry and not yet delivery)*	0.00000	0.00000	0.00000	0.71636	0.71636	0.7163641
P16	Prob. Transition from Giving birth to Post-abortion/delivery	0.00000	0.00000	0.00000	0.11575	0.11575	0.1157542
P17	Prob. Transition from Giving birth to Deceased	0.00000	0.00000	0.00000	0.00023	0.00023	0.0002334
P18	Prob. Transition from Post-abortion/delivery to Healthy	0.00000	0.00000	0.00000	0.03278	0.03278	0.03278
P19	Prob. Transition from Post-abortion/delivery to Post-abortion/delivery	0.00000	0.00000	0.00000	0.96719	0.96719	0.96719
P20	Prob. Transition from Post-abortion/delivery to Deceased	0.00000	0.00000	0.00000	0.00003	0.00003	0.00003
P21	Prob. Transition from HIV*(Asymptomatic or Untreated)* to HIV *(Asymptomatic or Untreated)*, remain HIV *(Asymptomatic or Untreated)*	0.80748	0.80748	0.80748	0.80748	0.99667	0.80748

No.	Parameter description	Male			Female		
		Level A	Level B	Level C	Level A	Level B	Level C
P22	Prob. Transition from HIV *(Asymptomatic or Untreated)* to HIV *(treated)*	0.18919	0.18919	0.18919	0.18919	0.18919	0.18919
P23	Prob. Transition from HIV *(Asymptomatic or Untreated)* to Deceased	0.00333	0.00333	0.00333	0.00333	0.00333	0.00333
P24	Prob. Transition from HIV *(Treated)* to HIV *(Treated)*, remain HIV *(Treated)*	0.99967	0.99967	0.99967	0.99967	0.99967	0.99967
P25	Prob. Transition from HIV *(Treated)* to Deceased	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
P26	Prob. Transition from Gonorrhea *(Asymptomatic or Untreated)* to Healthy	0.45000	0.45000	0.45000	0.16000	0.16000	0.16000
P27	Prob. Transition from Gonorrhea (*Asymptomatic or Untreated)* to Treated acute STDs	0.50000	0.50000	0.50000	0.20000	0.20000	0.20000
P28	Prob. Transition from Gonorrhea *(Asymptomatic or Untreated)* to PID	0.05000	0.05000	0.05000	0.16000	0.16000	0.16000
P29	Prob. Transition from Gonorrhea *(Asymptomatic or Untreated)* to Deceased	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P30	Prob. Transition from Chlamydia *(Asymptomatic or Untreated)* to Healthy	0.40000	0.40000	0.40000	0.48000	0.48000	0.48000
P31	Prob. Transition from Chlamydia *(Asymptomatic or Untreated)* to Treated Acute STDs	0.50000	0.50000	0.50000	0.20000	0.20000	0.20000

No.	Parameter description	Male			Female		
		Level A	Level B	Level C	Level A	Level B	Level C
P32	Prob. Transition from Chlamydia *(Asymptomatic or Untreated)* to PID	0.10000	0.10000	0.10000	0.32000	0.32000	0.32000
P33	Prob. Transition from Chlamydia *(Asymptomatic or Untreated)* to Deceased	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P34	Prob. Transition from Treated STDs to Healthy	0.87500	0.87500	0.87500	0.87500	0.87500	0.87500
P35	Prob. Transition from Treated STDs to PID	0.12500	0.12500	0.12500	0.12500	0.12500	0.12500
P36	Prob. Transition from Treated STDs to Deceased	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P37	Prob. Transition from PID to Healthy	0.93500	0.93500	0.93500	0.93500	0.93500	0.93500
P38	Prob. Transition from PID to PID, remain PID	0.06500	0.06500	0.06500	0.06500	0.06500	0.06500
P39	Prob. Transition from PID to Deceased	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
P40	Prob. Transition from Deceased to Deceased, remain Deceased	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

5.3.3. Costs

5.3.3.1. Intervention costs

The intervention costs of adolescent reproductive health interventions were calculated from the societal perspective for levels A, B and C separately. The costs were taken as incremental costs, as the intervention was implemented based on the existing primary health care system, the existing education system and intervention staff were all full-time staff of Hanoi School of Public Health. The intervention costs were calculated for two different cost norms: the Ford Foundation and the Vietnam Government cost norms, extracted from a number of the latest Vietnam Government's law references, such as Circular No. 58/2011/TT-BTC, Circular No. 139/2010-TT-BTC of Ministry of Finance. This study took into account two different cost-norms in order to increase the applicability of the results to the intervention provider team and local stake-holders when deciding whether to implement future interventions funded by international organisations or the Vietnam Government

The method for the intervention unit costs calculation and its results are explained in detail in Chapter 6.

5.3.3.2. Health-care costs

The health care costs were taken as incremental costs, as the treatment for diseases related to reproductive health were delivered based on the existing primary healthcare system. As the education intervention was delivered in Chi Linh, and all targeted adolescents were in Chi Linh, it was plausible to use the information from the government's law references, for instance the health care service charges for a provincial hospital, such as Chi Linh hospital.

The method for the health-care unit costs calculation is explained in detail in Chapter 6.

5.3.4. Values of health states

In order to ascertain the utility scores of each health state, (1) a 5-digit number corresponding to 5 dimensions of health state descriptive system, and (2) preference weights of choice were needed. Descriptions for each health state were retrieved from a small survey, in which, the indirect measurement approach using EQ-5D instrument was adopted. The method to undertake the survey and its results are explained in detail in Chapter 6.

5.3.5. Effectiveness of the education intervention

Based on the objectives of the reproductive health education intervention in Chi Linh (as mentioned in section 1.3.1), the effectiveness parameters of interest were:

1. Risk of becoming sexually active among adolescents within any 3 month period
2. Change in the proportion of having premarital sexual intercourses among adolescents in site B vs. site A, and site C vs. site A, for male and female groups, separately.
3. Change in the proportion of condom use among sexually active adolescents in their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
4. Change in the proportion of using condom properly/correctly among sexually active adolescents at their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
5. Change in the average number of sexual intercourse events within 3 months among sexually active adolescents in site B vs. site A, and site C vs. site A, for male and female groups, separately.
6. Change in the average number of partners per sexually active adolescent within the last 3 months in site B vs. site A, and site C vs. site A, for male and female groups, separately.

This research was initially designed to use the quasi-experimental design with pre and post-intervention evaluation of reproductive health knowledge and behaviours. However, due to some unexpected difficulties, including personnel and finance issues, the post intervention evaluation had not yet been done. Therefore, the actual data from the intervention was not available. Moreover, as the effectiveness of the reproductive health education intervention could not be reliably estimated from limited available literature in Vietnam, expert opinion was sought in order to estimate these parameters. A of prior elicitation technique, “structured questionnaires and pooling of opinion”, was used for that purpose (Spiegelhalter, Abrams, & Myles, 2004). The method used to undertake the expert elicitation and its results are explained in detail in Chapter 6.

5.3.6. Quality assessment of selected model parameters

The main tool used to assess data quality was the modified version of the hierarchies of evidence sources for economic analyses (N. Cooper, Coyle, Abrams, Mugford, & Sutton, 2005; Coyle & Lee, 2002) (Appendix 6). This tool provides a method for ranking the quality of data sources for clinical effect sizes, adverse events, complications, clinical estimates, resource estimates, costs and utilities. Data sources ranked 1 or 2 are high quality, a rank of 3 indicates medium quality and a rank of 4 or above represents low quality data. The following table summarises the level of evidence for all input parameters selected to inform the decision model.

Table 6: Summary of selected input parameters with quality assessment

<table>
<tr><th>Parameter description</th><th>Data source</th><th>Reference</th><th>Level of evidence</th></tr>
<tr><td colspan="4">Group 1: Transition probabilities</td></tr>
<tr><td>Probability of all causes mortality</td><td>Life Table of Vietnam, published in 2010, based on Vietnamese population in 2009</td><td>(World Health Organization, 2009)</td><td>1</td></tr>
<tr><td>Transition probability from not sexually active to sexually active</td><td>Author calculation based on primary and secondary sources from Chi Linh, Vietnam, and results from expert elicitation</td><td>(Le & Blum, 2009; Le et al., 2008), Chapter 6</td><td>1 and 6</td></tr>
<tr><td>Transition probability from healthy to pregnant</td><td>Author calculation using model developed by Wang et al based on primary and secondary sources from Vietnam, and results from expert elicitation</td><td>Chapter 6, (Becker, 1993; L.Y. Wang et al., 2000) (Ministry of Health et al., 2010)</td><td>1 and 6</td></tr>
<tr><td>Transition probability from healthy to HIV infection</td><td rowspan="2">Author calculation using Bernoulli model based on primary and secondary sources from Chi Linh, Vietnam, and results from expert elicitation</td><td rowspan="2">Chapter 6, (Bedimo et al., 2002; Brookmeyer & Gail, 1994; General Statistical Office et al., 2006; Le et al., 2008; Mastro & De Vincenzi, 1996; Pinkerton et al., 2004; Taege, 2011; World Health Organization, 2010)</td><td>1, 2 and 6</td></tr>
<tr><td>Transition probability from healthy to gonorrhea or chlamydia infection</td><td>1 and 6</td></tr>
<tr><td>All other transition probabilities</td><td>Author calculation based on primary and secondary sources from Vietnam, published articles and results from expert elicitation</td><td>(Howell, Quinn, Brathwaite, & Gaydos, 1998; Howell, Quinn, & Gaydos, 1998; Rodger et al., 2012)</td><td>1 and 6</td></tr>
</table>

Parameter description	Data source	Reference	Level of evidence
Group 2: Cost			
Intervention costs – costs incurred by intervention implementers	Author calculation based on primary and secondary sources from the real intervention in Chi Linh (the actual spending records of the intervention), the Ford Foundation cost norm, the Vietnam Government cost norm	The Ford Foundation cost norm, the Vietnam Government Circular No. 58/2011/TT-BTC, Circular No. 139/2010-TT-BTC of Ministry of Finance	1
Intervention costs – costs incurred by intervention participants			1
Health care costs – costs incurred by health care providers	Author calculation based on either recently published cost calculations based on reliable databases or health care service price list from Vietnam Ministry of Health and Vietnam Ministry of Finance for hospitals at provincial level or imported drug price lists.	Circular No. TTLT - 04 - BYTBTC from Vietnam Ministry of Health and Vietnam Ministry of Finance	1
Health care costs – costs incurred by patients and families	Author calculation based on either the survey of 108 randomly chosen patients receiving health care services at a local health facility or health care experts' interviews		1
Group 3: Values of health states			
Utility scores	Author calculation based on: (1) Health state description for each state was retrieved from primary data from a survey using EQ-5D questionnaire, (2) Preference weight of choice was adopted from the population-base South Korea time trade-off values for EQ-5D health states	(Cheung et al., 2009; Lee et al., 2009)	1 and 3
Group 4: Effectiveness of the education intervention			
Effectiveness of the education intervention	Author calculation based on results from the expert elicitation	Chapter 6	6

5.4. Model evaluation methods

5.4.1. Deterministic analysis

The point estimate of the incremental cost utility ratios (ICER) was first calculated based on a series of assumptions without considering any form of uncertainty. The ICER was calculated by taking the incremental change in costs divided by incremental change in benefits. The calculation of ICER used the formula:

$$\mathbf{ICER} = \frac{\sum \mathbf{COST\ 1} - \sum \mathbf{COST\ 2}}{\sum \mathbf{QALY\ 1} - \sum \mathbf{QALY\ 2}}$$

Where ∑ ***COST 1*** referred to the total costs of the competing intervention,

∑ ***COST 2*** referred to the total costs of the control intervention

∑***QALY 1*** referred to the total quality-adjusted life years of the population in the competing intervention

∑***QALY 2*** referred to the total quality-adjusted life years of the population in the control intervention

Using the above formula, two scenarios could be compared at a time. The first round of calculation was done to compare intervention B to A and the second round of calculation was done to compare intervention C to B. All calculations were done for male adolescents only, female adolescents only and then for both male and female adolescents.

The total costs in each intervention level were calculated from the societal perspective, using two different cost norms from the Ford Foundation and the Vietnam Government for the calculation of intervention costs. From the societal perspective, the total costs were computed using the following formula:

$$\textbf{Total Costs} = \textbf{Total Intervention Costs (C)} + \textbf{Total Health Care Costs (B)}$$

The total quality-adjusted life years of the cohort in each intervention level were calculated using cohort simulations. A notational population of 100,000 adolescents, equally divided into two groups of male and female adolescents was used as the starting cohort. The proportions of the cohort in various states for each 3-month cycle were calculated based on the proportions of the previous cycle and the corresponding transition probabilities. The point/expected estimate of the quality-adjusted life years for each cycle, therefore, were summed by adding the quality weight of each health state multiplied by the proportion in that state. The total quality-adjusted life years for the whole cohort were calculated by summing across cycles (i.e. 55 cycles for male and 40 cycles for female).

Following this, a threshold of incremental cost-utility ratio, λ, in order to classify health care intervention into an effectiveness group in the Vietnamese context was set based on the cost-effectiveness threshold suggested by the World Health Organisation (World Health Organization). WHO uses gross domestic product (GDP) as a readily available indicator to derive the following three categories of cost-effectiveness: highly cost-effective (less than one time GDP per capita); cost-effective (between one and three times GDP per capita); and not cost-effective (more than three times GDP per capita). As this analysis was done for the intervention in 2011, the GDP per capita of Vietnam was US$1,596 (The World Bank), equivalent to AUD1,755 (using the exchange rate reported for 2011 (United Nations Treasury, 2013)). In other words, the education intervention was considered highly cost-effective if the ICER was less than the willingness-to-pay threshold of AUD1,755, cost-effective if the ICER was between AUD1,755 and AUD5,265, and not cost-effective if ICER was more than the willingness-to-pay threshold of AUD5,265.

5.4.2. Probabilistic sensitivity analysis

The main objective of this specific step was to incorporate ***uncertainty analysis*** into the modelling process and quantify the effect of uncertainty on the incremental cost-utility ratio (ICER) between different intervention approaches of the adolescent reproductive health education intervention in Chi Linh, Vietnam. Therefore, probabilistic sensitivity analysis (PSA) approaches were adopted in order to evaluate the impact of uncertainty around the epidemiological and costing estimates on the final results (e.g. ICER). In the previous analysis (section 5.4.1), point estimates were calculated to report costs, health benefits and ultimately, the incremental cost-utility ratios for the different levels of educational intervention. As these calculations were based on many assumptions and estimates, there was uncertainty associated with both cost and outcome estimates. To examine the impact of uncertainty on the final results, simulation modelling techniques were used to present uncertainty around each incremental cost-utility ratio reflecting all of the main sources of uncertainty in the calculations.

Estimates and assumptions of input parameters were entered as probability distributions in a spread sheet. The choice of probability distributions around the input parameters are presented in the following tables (adapted from Briggs et al (2006b)). Due to the *Central Limit Theorem*, normal distribution could be applied for any model parameter.

Table 7: Probability distributions around the input parameters

Parameter	Form of data and method of estimation	Candidate distribution
Group 1: Transition probabilities		
Probability ($0 \leq \pi \leq 1$)	Binomial/Multinomial: estimated proportion/s Time to event: survival analysis	Beta(α,β),α,β>0 Dirichlet(α1,…αk),αk>0 Lognormal(lm,lv),lm,lv>0
Group 2: Costs		
Cost ($0 \leq \theta \leq +\infty$)	Weighted sum of resource counts: mean	Gamma(α,β),α,β>0 Lognormal(lm,lv),lm,lv>0
Group 3: Effectiveness		
Effectiveness of the intervention - expert elicitation	Continuous non-zero: mean	Lognormal(lm,lv),lm,lv>0 Normal(μ,σ^2), $\sigma^2>0$
Utility decrement/ Disutility (($0 \leq \theta \leq 1$)	Continuous non-zero: mean	Gamma(α,β),α,β>0 Lognormal(lm,lv),lm,lv>0
Or Utility	Continuous non-zero: mean	Beta(α,β),α,β>0
Other parameters	Any distribution of data	Normal(μ,σ^2), $\sigma^2>0$

Once distributions were fitted around model parameters, values were drawn randomly from these distributions, using the Monte Carlo simulation. This was a straight forward repetitive process and was achieved in Microsoft Excel using programs known as “macros” (Appendix 7).

The model was recalculated on the spread sheet 1,000 times - each time picking a value out of all defined probability distributions - and a full record of all the probabilistic output of the probabilistic model was established.

Analysis and present simulation output from probabilistic models was then undertaken. Firstly, the estimated joint cost-effectiveness values generated by the iterations were plotted on the cost-effectiveness plane (Black, 1990) together with the threshold ratio, λ. The threshold ratio, λ, sometimes termed as “a ceiling ratio”, the maximum willingness-to-pay by decision-makers, is added to the cost-effectiveness plane and the joint density shows if the intervention is cost-effective.

Secondly, the concept of net monetary benefit (NMB) was also adopted. The algebraic formulation of the decision rule for cost-effectiveness analysis, which is a new intervention and should only be implemented if its ICER lies below the threshold ratio, λ, was rearranged as follow:

$$\boldsymbol{ICUR} = \frac{\boldsymbol{\sum Cost\ 1 - \sum Cost\ 2}}{\boldsymbol{\sum QALY\ 1 - \sum QALY\ 2}} = \frac{\Delta \boldsymbol{C}}{\Delta \boldsymbol{E}} < \boldsymbol{\lambda}$$

Net monetary benefit (NMB) could thus be calculated using the following equation:

$$\boldsymbol{NMB} = \boldsymbol{\lambda} * \Delta \boldsymbol{E} - \Delta \boldsymbol{C} > 0$$

Where $\Delta \boldsymbol{C}$ and $\Delta \boldsymbol{E}$ represented the incremental costs and incremental health benefits, respectively and $\boldsymbol{\lambda}$ was the decision maker’s ICER threshold.

A positive NMB means that an intervention is cost-effective and a negative NMB means that this intervention is not cost-effective. Moreover, a cost-effectiveness acceptability curve (CEAC) (Van Hout et al., 1994), which directly summarises the evidence in support of the intervention being cost-effective for different values of the cost-effectiveness threshold, was developed to illustrate the result of the Monte Carlo simulation. However, this analysis involved three mutually exclusive options and Barton (2008) suggested that the CEAC should not be used to identify the optimal option. Therefore, a cost-effectiveness acceptability frontier (CEAF) was adopted. At this step, the value of threshold ratio, λ, was varied in order to create a graph with a CEAF, which was equivalent to plotting each cost-effectiveness acceptability curve (CEAC) over the range of values for the cost-effectiveness threshold for which each option was estimated to be the most cost-effective.

5.4.3. Scenario analysis

The input parameters on effectiveness of the reproductive health education intervention were ascertained from the expert elicitation, which relied heavily on different assumptions and expert opinions. However, they were of much interest in this study. Therefore, a scenario analysis approach was used in this research. The scenario analysis allowed all six parameters related to the effectiveness of the reproductive health education intervention to vary simultaneously over a range to determine at what values conclusions of cost-effectiveness analysis might change. The range for the effectiveness parameters was better or worse by 10%, 20%, 30%.

Based on the results of the scenario analysis, the required effectiveness for the adolescent reproductive health intervention to be supported for widespread adoption was identified. The required effectiveness for the adolescent reproductive health education intervention was compared with the prior elicitation on effectiveness of the intervention, (discusses in Chapter 6), in order to examine the likelihood of this intervention being cost-effective in reality.

5.4.4. Value of information analysis

This analysis step involved the assessment of the value of perfect information and to propose recommendations for further data collection or future research in order for local stakeholders to be certain about an investment of scarce resources into adolescent reproductive health interventions in other communities. The value of perfect information among model parameters for making final decisions, sometimes termed “the cost of uncertainty”, which is a measurement of the consequences of making a “wrong” decision that would result in wasting resources and health benefits (A. Briggs et al., 2006a), is also important. A technique called the Expected Value of Perfect Information (EVPI) was adopted in this step. The EVPI was derived directly from the simulated output from the model without the fulfilment of assumptions of normality, using a nonparametric approach.

Theoretically, the expected cost of uncertainty was calculated by multiplying the cost of uncertainty and probability of making the wrong decision.

$$\textbf{\textit{The expected cost of uncertainty}} = \textbf{\textit{Probability of making a wrong decision}} \times \textbf{\textit{Cost of uncertainty}}$$

Practically, the expected cost of uncertainty was simply the difference between the expected value of the decision made with perfect information about the uncertain parameters θ, (e.g. the expected net benefit with perfect information, as calculated in 5.4.2), and the decision made on the basis of existing information, (e.g. the expected net benefit with current information, as calculated in 5.4.2):

$$\boldsymbol{EVPI = E_{\theta} max_{j} NB(j, \theta) - max_{j} E_{\theta} NB(j, \theta)}$$

All analyses were conducted in Microsoft Excel 2007 using a series of linked Excel spread sheets. Macros in visual basis language were also used to record repeated results from the simulations. The results of the EVPI calculation could result in two conclusions. First, answering the question of which type of reproductive health education interventions for adolescents was more cost-effective and should be expanded to other areas. Second, identifying further data needs to be collected to enable greater certainty about the cost-effectiveness of different levels of adolescent reproductive health interventions. In order to reduce the uncertainty, follow-up research to measure the exact change in reproductive health behaviours of participants in the education interventions could be undertaken in the future. By comparing EVPI with the cost of undertaking further research to reduce the uncertainty, a recommendation on whether it was potentially worthwhile to undertake that research was made.

5.5. Summary

This chapter has described the process of developing a decision model capable of capturing the key events related to a decision problem. The model was validated by experts and described in detail. All of the input parameters, methods and data sources for archiving those input parameters were explained. Overall, the model input parameters were of high quality and represented appropriate data sources to inform the decision model.

Moreover, the methods used to evaluate the cost-effectiveness of the different levels of reproductive health education intervention, quantify the decision uncertainty, and estimate the EVPI were described and justified. Incremental cost – utility ratios of the interventions were first calculated for education intervention level B versus level A, and then level C versus level B, for males, females and both males and females, using two different cost norms, separately. Uncertainty surrounding the parameters was dealt with using PSA and uncertainty relating to the effectiveness of the intervention was handled using one-way sensitivity analysis (the scenario analysis). Finally, EVPI for the whole model parameters were estimated to inform priority setting in further research in this area.

Chapter 6 – The estimation of costs, health related quality of life and effectiveness of the education interventions

This chapter describes the methods used to estimate the costs from the intervention participants', and health care patients and families' perspectives (6.1), the intervention costs from the intervention implementers' perspective (6.2), and the health care costs from the health care providers' perspective (6.3). The methods involved to estimate health related quality of life are presented (6.4), followed by the methods and results of the elicitation of expert opinions on the effectiveness of the intervention (6.5). A summary of the overall methods and results concludes the chapter (6.5).

The estimations in sections 6.1, 6.2 and 6.3 were necessary to fulfil the following research tasks:

- ❖ **Task one**: Calculate the intervention unit costs from the societal perspective of adolescent reproductive health intervention.
- ❖ **Task two:** Calculate the health-care unit costs (e.g. treatment cost for HIV, other STDs, PID, abortion and giving birth) from the societal perspective.

The estimation in part 6.4 was done in order to fulfil the following research tasks:

- ❖ **Task three:** Measure health-related quality of life (HRQL) for each health state of interest using primary data combined with existing evidence from the perspective of adolescents in Chi Linh, Vietnam.

The estimation in part 6.5 directly addressed the following research task:

- ❖ **Task six:** Elicit expert opinions about the effectiveness of the adolescent reproductive health education interventions.

Ethical approval: An application for low risk research involving human participants was approved by both the University Human Research Ethics Committee (UHREC) at QUT (Appendix 8 – NHMRC registered committee number EC00171) and the University Human Research Ethics Committee at Hanoi School of Public Health (Appendix 9) before all of the following primary data collection presented in this chapter was undertaken.

6.1. Estimation of costs incurred by intervention participants and health-care patients and families

Costs incurred by intervention participants were cost of transportation and opportunity cost associated with the client's participation in the intervention. Costs incurred by health-care patients and families were costs of transportation, meals, accommodation used by patients during treatment for that disease and costs of lost productivity (paid or unpaid) resulting from morbidity or mortality. Those costs were needed for the calculation of the intervention costs (part 6.2) and the health care costs (part 6.3).

6.1.1. Method

The required costs were calculated based on data from a cross-sectional hospital-based survey.

Survey site and target population: Participants in this survey were patients and family members, who received health care services at Chi Linh hospital (a provincial hospital, closed to all of the intervention sites).

Sample size and sampling: Convenience sampling was adopted. To be included in this survey, the inpatients had to have been discharged from Chi Linh hospital during the period of data collection, August to November 2013. All patients and family members who had mental or communication problems, or were under 6 years of age were excluded. The survey was comprised of 109 patients.

Survey instrument: Interviews were conducted using structured questionnaires (Appendix 10) comprised of two parts. The first part included questions about demographic and socio-economic characteristics and the second part included questions about means of transportation to the hospital, distance from home to the hospital, transportation and meal costs, number of days absent for taking care of patients and other information for cost calculation.

Data collection mode: The interviews were conducted as close as possible to the date of discharge in order to have comprehensive information about costs paid by both patients and family members. In most cases, interviews took place on the day of discharge for inpatient health service patients or 20–30 minutes just prior to discharge for outpatient health services patients. All participants were interviewed by the researcher.

Data analysis: All costs were originally estimated in terms of Vietnamese Dong. To enhance the comparability of this research, the estimates were converted to Australian Dollars (AUD) according to the average exchange rate in 2011 (United Nations Treasury, 2013). Data on cost were calculated using the costing template in Microsoft Excel 2007 (Appendix 11).

6.1.2. Results

The demographic, socio-economic characteristics and number of hospital days of the survey sample is presented in the following table.

Table 8: Demographic, socio-economic characteristics of survey sample

Characteristic (n = 109)		**n (%)**
Female		80 (73.4)
Education		
	None or finished primary school	16 (14.7)
	Finished secondary and high school	69 (63.3)
	College/university	24 (22.0)
Household monthly income		
	Mean (SD) [range]	335 (235) [10 – 1,593]
Number of hospital days		
	Mean (SD) [range]	32 (21.0) [2 – 71]
Having health insurance cards		57 (52.3)

The survey sample included 109 patients, of which 74.3% were female and 85.3% finished secondary or high school or college. Approximately 52% of patients had health insurance cards, which covered some costs related to hospitalisation. The mean household monthly income was AUD335 (SD = AUD235). The average length of hospitalisation was 32 days.

The estimation of costs from intervention participants' perspective and costs from health-care patients and families' perspective are shown in Table 9.

Table 9: Costs from intervention participants' perspective and costs from health-care patients and families' perspective

Cost items	Median/ mean	SD
Cost incurred by intervention participants - Cost of Transportation *(per session)*		
Distance from home to intervention venue (kilometre)	2.33	0.15
Cost of transportation (by motorbike) for 1 kilometre (in AUD)	0.078	0.002
Cost of transportation (by bicycle) for 1 kilometre (in AUD)	0.00	0.00
Cost incurred by health care patients - Cost of Transportation *(per day)*		
Distance from home to provincial hospital (kilometre)	6.22	1.13
Cost of transportation (by motorbike) for 1 kilometre (in AUD)	0.078	0.002
Number of patients and family carers (person)	2.1	0.45
Cost incurred by health care patients - Cost of Meals, Accommodation		
Cost of meals, accommodation (per day per person) (in AUD)	2.78	1.02
Cost incurred by health care patients – Cost of productivity lost		
Cost of productivity lost (per day per person) (in AUD)	4.8	0.76

Those estimates were used in the calculation of total intervention cost and total health care cost in each intervention area. Due to the fact that there is only one provincial hospital for all 7 communes and towns, but there are several secondary and high schools in each commune and town in Chi Linh, the distance from enrolled participants' home to the intervention venue (2.33 kilometres) is much shorter than from home to the hospital (6.22 kilometres). Cost of transportation for the intervention participants is presented as two separate items, travelling by bicycle for the school students and travelling by motorbike for the students' parents.

6.2. Estimation of the intervention costs

6.2.1. Method

The ***intervention costs*** of education interventions were calculated from the societal perspective for sites A, B and C separately.

The costs were taken as incremental costs. The intervention costs were calculated for two different cost norms, the Ford Foundation cost norm and the Vietnam Government cost norm, derived from a number of the most recent Vietnam Government's law references, such as Circular No. 58/2011/TT-BTC, Circular No. 139/2010-TT-BTC of Ministry of Finance.

From the societal perspective, the total cost of the intervention included costs from intervention implementers' perspective and costs from the intervention participants' perspective (as shown in Equation 1)

Total intervention cost	=	***Costs incurred by intervention implementers (C1)***	+	***Costs incurred by intervention participants (C2)***	***(1)***

Costs incurred by intervention implementers (C1) included intervention staff compensation and field staff compensation, facility-related costs (rent, utilities), materials (such as hand-books for school teachers, training manuals for school students, posters for Youth Friendly corners, pamphlets for student's parents, etc.). However, those costs excluded staff salary and general overhead cost as the intervention was implemented based on the existing primary health care and education system. Data for the calculations were derived from actual spending records provided by the intervention implementers for the Ford Foundation cost norm or from the Circulars of Ministry of Finance for the Vietnam Government cost norm.

Costs incurred by intervention participants (C2) included cost of transportation for participants and opportunity cost associated with the client's participation in the intervention. Cost of transportation for participants (students, teachers, and students' parents) was calculated by taking the average cost of transportation from home to the intervention venue and was collected by survey. In this intervention, all participants, regardless of whether they were school-teachers or students or parents, were provided with incentives; therefore, such incentive payments could be considered a proxy for the opportunity cost of participation. Data for this part of costing was collected either from the actual spending records of the intervention and results from section 6.1.

The ***intervention unit cost*** was calculated by taking the total cost of the intervention divided by the number of intervention participants. The number of participants was 3,159; 1,695; and 5,119 in sites A, B and C, respectively (equation 2). The calculation of the intervention unit cost was undertaken as it was necessary to use that result in order to estimate the total intervention cost in different scenarios, e.g. other populations if this type of intervention is adopted in other settings.

$$\textbf{\textit{Intervention unit-cost}} = \frac{\textbf{\textit{Total intervention cost (Equation 1)}}}{\textbf{\textit{Number of intervention participants}}} \qquad \textbf{\textit{(2)}}$$

In order to collect the intervention costs accurately and adequately, each cost item was documented and calculated on the actual-activity basis using the micro-costing approach.

Time horizon for the costing was 12 months for intervention preparation and 12 months for intervention implementation. All costs were originally measured in terms of Vietnamese Dong in 2011. The results were then converted to Australian Dollars (AUD) according to the exchange rate in 2011 in order to enhance the comparability of this research. Data on cost was managed and calculated using the costing template in Microsoft Excel 2007 (Appendix 11).

6.2.2. Results

Results of intervention cost calculation are shown in Table 10.

***Table 10**: Intervention costs associated each level of education intervention*

Cost items	Site A	Site B	Site C
Costs incurred by intervention implementers (Ford Foundation cost norm)			
Total fixed cost *(in AUD)*	0.00	36,432.00	52,511.25
Variable cost per participant *(in AUD)*	0.00	5.22	8.01
Costs incurred by intervention implementers (Vietnam Government cost norm)			
Total fixed cost *(in AUD)*	0.00	27,551.82	39,231.94
Variable cost per participant *(in AUD)*	0.00	1.63	2.64
Costs incurred by intervention participants *(in AUD)*	0.00	0.63	1.27

When using the Ford Foundation cost norm, the estimation of total fixed cost and variable cost per participant from intervention implementers was 30% and 3 times respectively higher than when using the Vietnam Government cost norm. The difference in the results was due to the difference in the payment rate of the two cost norms. When comparing intervention levels, the costs at level C were always higher than level B and level A. The differences were attributable to more activities included (not only school-based and community-based activities but also health-facility-based activities), more participants involved (not only school teachers or students' parents but also health care providers, gender experts) in intervention level C in relation to the others.

6.3. Estimation of the health-care costs

6.3.1. Method

The ***health-care unit costs*** (e.g. treatment cost for HIV infection, other STDs, PID, abortion and giving birth) were taken as incremental costs, as treatments for diseases related to reproductive health were delivered based on the existing primary healthcare system.

From the societal perspective, the treatment cost for diseases and conditions related to reproductive health included health care resource use (e.g. hospital resources), and patient and family resource use (e.g. transportation, sick absence and care givers) (as shown in equation 3)

$$\textit{Health care unit cost} = \textit{Costs incurred by health care providers (B1)} + \textit{Costs incurred by patients and families (B2)} \quad (3)$$

Costs incurred by health care providers (B1) included costs of diagnosis, treatment, follow-up, rehabilitation, and terminal care. It is worth noting that as the treatment for diseases of interest was delivered based on the existing primary healthcare system, overhead costs (such as costs raised from supporting departments like general administration, housekeeping, laundry or maintenance) were excluded from the calculation. Data for this part of the calculation were collected from either recently published cost calculations based on reliable databases or data sources (where possible), or health care service charges from Circular No. TTLT - 04 - BYTBTC from the Vietnam Ministry of Health and Vietnam Ministry of Finance (see Appendix 14).

Costs incurred by patients and families (B2) included costs of transportation, meals, accommodation used by patients during treatment for that disease and costs of lost productivity (paid or unpaid) resulting from morbidity or mortality (Berger et al., 2003). Data for these costs was taken from section 6.1.

The cost calculation was undertaken using three main steps: identifying, measuring and valuing all resources used for the treatment of adverse health states. All costs were originally measured in terms of Vietnamese Dong in 2011. As data used for this cost calculation was from the Vietnam Government's law references in 2010 or 2011, it did not need adjustment to the reference year, which was also 2011. All costs were originally measured in terms of Vietnamese Dong and subsequently converted to Australian Dollars (AUD). Data on cost was managed and calculated using the costing template in Microsoft Excel 2007.

6.3.2. Result

Results of health–care cost calculations are shown in Table 11.

Table 11: Additional health care costs associated with health states (per case)

Cost items	Costs incurred by health care providers	Costs incurred by patients and families	Total costs (AUD)
Cost per Healthy case (B1)	0.00	0.00	0.00
Cost per Abortion case (B2)	24.45	30.43	54.88
Cost per Giving birth case (B3)	63.71	152.15	215.86
Cost per Post-abortion/delivery case (B4)	31.97	19.10	51.07
Cost per HIV infection (Asymptomatic or untreated) (B5)	26.05	53.09	79.14
Cost per HIV infection (Treated) (B6)	148.94	146.85	295.79
Cost per Gonorrhea/Chlamydia (Untreated) (B7)	0.00	0.00	0.00
Cost per Gonorrhea (Treated) (B8)	11.60	11.17	22.77
Cost per Chlamydia (Treated) (B9)	8.17	11.17	19.34
Cost per PID treatment case (B10)	45.03	156.47	201.50
Cost per Deceased case (B11)	0.00	0.00	0.00

In most cost items, costs incurred by patients and family members were equal or higher than costs incurred by health care providers. Of significance, costs per giving birth case and costs per PID treatment case incurred by patients and family members were 2.5 times higher than costs incurred by health care providers. The difference was due to the fact that these treatments required inpatient care and family members needed to take care of the patients during the hospitalisation period.

6.4. Estimation of health related quality of life – utility scores

6.4.1. Method

The elicitation of utility scores for health states included in the Markov model was undertaken using a two stage process. First, collection of the 5-digit number corresponding to 5 dimensions of health state description. Second, calculation of the health related quality of life using an appropriate preference weight.

(1) The descriptions for each health state from the perspective of Vietnamese adolescents were collected using a cross-sectional survey.

Survey site and target population for this survey was, “hypothetical patients”, e.g. adolescents in grade 11 in Chi Linh. The 16 years old students was chosen in order to make sure they could understand the process and be able to imagine consequences of each health state of interest and thus could complete the questionnaire accurately. They were also the participants in the reproductive health education intervention.

Sample size and sampling: Convenience sampling was adopted. There are three high-schools, one in intervention site B and two in intervention site C. Each high-school consists of several 45-student classes. In each high-school, two grade 11 classes were chosen randomly for a total of six classes consisting of 270 students. Two classes in each school were divided randomly into group 1 and 2.

Survey instrument: the Vietnamese version of EQ-5D was retrieved from the official EuroQoL website (Appendix 12). The EQ-5D questionnaire defines the state of health across five dimensions: mobility (M), self-care (SC), usual activities (UA), pain/discomfort (PD) and anxiety/depression (AD).

Each dimension has three levels: no problems (level 1), some problems (level 2), and severe problems (level 3). Students in group 1 were asked to express their subjective assessments over seven different health states of interest: “their own health state today”, healthy, unintended abortion, giving birth, post-abortion/delivery, HIV infection (unknown or asymptomatic), and HIV infection (known). While students in group 2 were asked to express their subjective assessments over seven different health states of interest: “their own health state today”, healthy, gonorrhea infection (asymptomatic or untreated), chlamydia infection (asymptomatic or untreated), gonorrhea infection (treated), chlamydia infection (treated), PID.

Data collection mode: EQ-5D was primarily designed for self-completion. In this survey, on every odd page (the EQ-5D descriptive system), grade 11 students were asked to express their subjective assessments over different health states of interest by ticking (or placing a cross) in the box against the most appropriate statement in each of the 5 dimensions and on every even page (the EQ-5D visual analogue scale), they were asked to rate these health states on a vertical, visual analogue scale where the endpoints were labelled "Best imaginable health state" and "Worst imaginable health state".

Data were collected between September and October, 2013 by the researcher. After obtaining permission from the heads of schools and teachers, the researcher asked enrolled students to complete anonymous self-administered questionnaires in a classroom setting during a scheduled class time.

Data management: Values collected from the survey instrument were recorded using the Microsoft Excel software package.

Logical consistency and exclusion criteria: The logical consistency approach was applied to examine the quality of data. Logical consistency is defined as if health state A (for example, HIV infection) is clinically worse than health state B (for example, chlamydia), then the utility score calculated for health state A must be lower than for health state B.

Questionnaires were excluded if they answered less than six health states, valued all states the same, or if there were two or more logical inconsistencies. These exclusion criteria took into account responses with incomplete or unreliable data.

(2) Calculation of health related quality of life

Data gained from questionnaire surveys can be converted into a utility index score by using scores from value sets (preference weights) elicited from a general population. Unfortunately, preference weights of EQ-5D for Vietnamese people are not yet available. Fortunately, among countries with available population-based EQ-5D references, regarding cultural dimensions, South Korea has close scores with Vietnam. Therefore, the time trade-off valuation set from South Korea was adopted.

In 2009, Lee et al. conducted a study to establish South Korean population-based preference weights for EQ-5D based on values elicited from a representative national sample using the time trade-off (TTO) method. Various regression techniques and model specifications were also examined in order to produce the best fit model. Final model selection, the N3 Model, was based on minimising the difference between the observed and estimated value for each health state.

Parameter estimates of aggregate level of N3 model is:

$$
\begin{aligned}
\text{Disutility} = 0.05 \quad & + 0.096{*}M2 && + 0.418{*}M3 \\
& + 0.046{*}SC2 && + 0.136{*}SC3 \\
& + 0.051{*}UA2 && + 0.208{*}UA3 \\
& + 0.037{*}PD2 && + 0.1518PD3 \\
& + 0.043{*}AD2 && + 0.158{*}AD3 \\
& + 0.05 * N3 &&
\end{aligned}
$$

Where:

M2, M3 is mobility on level 2 (some problems), level 3 (severe problems), respectively;

SC2, SC3 is self-care on level 2 (some problems), level 3 (severe problems), respectively;

UA2, UA3 is usual activities on level 2 (some problems), level 3 (severe problems), respectively;

PD2, PD3 is pain or discomfort on level 2 (some problems), level 3 (severe problems), respectively;

AD2, AD3 is anxiety or depression on level 2 (some problems), level 3 (severe problems), respectively;

N3 is any dimension on level 3 (severe problems).

Each parameter estimate was reported with its own standard errors, which were later used for the uncertainty analysis. A quality weight for each state was then calculated in Microsoft Excel using results retrieved from the survey and the South Korean preference weights.

6.4.2. Result

General information of the survey sample is shown in Table 12.

Table 12: Number of EQ – 5D questionnaires distributed and response rate

	Group 1 - Pregnant	Group 2 - STDs	Total
Ben Tam – site B	50	48	98
Tran Phu – site C	47	49	96
Chi Linh – site C	45	46	91
Total	142	143	285
Eligible (n/%)	134 (94.3%)	131 (91.6%)	265 (93%)

The number of questionnaires in group 1 and group 2 were mostly equal. 285 questionnaires were delivered and all (100%) were returned to the researcher, however, some of the questionnaires were excluded from the analysis due to the exclusion criteria. The inclusion rates or response rates were higher than 90% in both group 1 and group 2, resulting in a 93% overall response rate.

The result of health – related quality of life (HRQL) estimation is shown in Table 13. Compared to other health states of interest, the mean utility score calculated for "healthy" state was the highest, followed by the mean utility score of "current health state". The difference between the mean utility scores of "healthy" and "current health state" was not remarkable, indicating enrolled students self-evaluated their health state as relatively good. The result seems to be logically consistent as clinically worse health states are scored at lower values than others.

Table 13: Health-related quality of life estimation associated with each health state in the Model

Health state code	Number of Respondent	EQ-VAS	Morbidity	Self-care	Activity	Pain	Anxiety	Disutility				Utility
								Mean	SD	95%CI - Lower	95% CI - Upper	
Healthy (U1)	265	96.272	1.008	1.011	1.023	1.038	1.106	0.058	0.024	0.01190	0.105	0.942
Abortion (U2)	134	69.455	1.746	1.448	1.784	1.776	2.388	0.323	0.130	0.06927	0.578	0.677
Giving birth (U3)	134	65.759	1.692	1.526	1.872	1.842	2.338	0.327	0.123	0.08537	0.569	0.673
Post-abortion/delivery (U4)	134	64.507	1.769	1.582	1.828	1.918	2.321	0.342	0.153	0.04228	0.642	0.658
HIV (Asymptomatic) (U5)	134	73.791	1.097	1.134	1.366	1.351	1.701	0.156	0.121	-0.0813	0.394	0.844
HIV (Being Treated) (U6)	134	48.485	1.761	1.604	2.015	2.216	2.784	0.494	0.222	0.05973	0.929	0.506
Gonorrhea (Asymptomatic) (U7)	131	75.611	1.435	1.466	1.656	1.718	1.939	0.226	0.117	-0.0027	0.455	0.774
Chlamydia (Asymptomatic) (U8)	131	78.924	1.344	1.481	1.611	1.687	1.756	0.197	0.104	-0.0071	0.401	0.803
Acute STDs (Being treated) (U9)	262	82.920	1.233	1.256	1.382	1.561	1.836	0.163	0.091	-0.0150	0.340	0.837
PID (U10)	131	69.580	1.725	1.702	1.756	2.015	2.076	0.299	0.117	0.06983	0.528	0.701
Dead (U11)	131	0.405	3.000	2.992	3.000	2.954	2.947	1.159	0.864	-0.5346	2.852	-0.159
Current health state (U0)	265	92.426	1.023	1.004	1.034	1.057	1.215	0.066	0.031	0.00553	0.126	0.934

6.5. Elicitation of expert opinion for the effectiveness of the intervention

6.5.1. Method

As mentioned in section 5.3.4.1, the effectiveness of the reproductive health education intervention could not be measured directly in Chi Linh, and it could not be reliably estimated from the limited available literature in Vietnam. The alternative method used was to elicit expert opinion, with uncertainty, to estimate these parameters.

Based on the objectives of the reproductive health education intervention in Chi Linh, the parameters that needed to be addressed were:

1. Risk of becoming sexually active among adolescents within any 3 month period
2. Change in the proportion of having premarital sexual intercourse among adolescents in site B vs. site A, and site C vs. site A, for male and female groups, separately.
3. Change in the proportion of condom use among sexually active adolescents in their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
4. Change in the proportion of using condom properly/correctly among sexually active adolescents at their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
5. Change in the average number of sexual intercourse events within 3 months among sexually active adolescents in site B vs. site A, and site C vs. site A, for male and female groups, separately.
6. Change in the average number of partners per sexually active adolescent within the last 3 months in site B vs. site A, and site C vs. site A, for male and female groups, separately.

Sample size and sampling: A prior elicitation technique; “structured questionnaires and pooling of opinion”, was used for this purpose (Spiegelhalter et al., 2004). The selection of key informants did not involve random sampling as the interview did not serve the purpose of generalisation of results (Spiegelhalter et al., 2004). The sampling was done on the basis of convenience criteria. Fourteen experts with backgrounds and experience in health promotion (i.e. health education interventions) and/or reproductive health among adolescents were contacted for the interview. These experts were staff from the health education department - Ministry of Health, reproductive health department – Ministry of Health, public health academic institutions, Health Strategy and Policy Institution.

Interview instrument: Based on the questionnaire format of some previous expert elicitation studies (Chaloner & Rhame, 2001; Parmar et al., 2001; White, Carpenter, Evans, & Schroter, 2007), a structured questionnaire was developed. The questionnaire consisted of an information sheet, which was a short summary of the goal, the targeted participants and the main activities of the reproductive health education intervention, followed by six main questions. The experts were asked to provide their estimates on the expected effectiveness of the reproductive health education intervention. Experts were invited to distribute 100 points between several complementary intervals, indicating their "weight of belief" in the possible effectiveness of the education interventions in Chi Linh (Appendix 13). As suggested by previous researchers, in order to achieve more precise information (Spiegelhalter et al., 2004) experts were reminded to ignore the role of sampling variability and a hypothetical example was included in the questionnaire.

Two experts in health economics and epidemiology provided technical input on the English version of the questionnaire. The questionnaire was finalised and translated by the researcher. Three Vietnamese PhD students at Queensland University of Technology (QUT) then reviewed the translation and questionnaire content and their feedback was incorporated into the final design.

Before the actual interviews, the questionnaire was pre-tested on two other PhD students at QUT to assess the flow and clarity of the interview structure. Based on their comments, the questionnaire was refined in both the phrasing of questions and the data collection mode. Due to the complexity of the questionnaire, it was not feasible to ask the experts to complete the self-administered questionnaire.

Data collection mode: The mode of data collection was a face-to-face interview. Selected experts were contacted and asked to provide informed verbal consent to a face-to-face interview. The venue and time for the interview were arranged according to convenience of the interviewee, normally at the interviewee's institution. The interviews were conducted by the researcher and on average took 30–45 minutes.

Data analysis: With varying prior distributions elicited from multiple experts, one of all possible strategies; arithmetic pooling was adopted. This method simply took the average of the height of the prior distributions for each parameter value θ, so that $p(\theta) = \sum_k p_k(\theta)/K$, with K ass the number of participating experts. The prior distribution with its mean and standard deviation were identified and used for uncertainty analysis.

6.5.2. Result

Table 14 shows selected experts according to their profession and institution.

Table 14: General information of experts selected for interviews

Institution in Vietnam	No. of experts (n = 14)	Professional group
Ministry of Health	2	Health promotion
	2	Reproductive health
Health strategy and policy institution	1	Health promotion
	1	Reproductive health
Academic institution	2	Health promotion
	1	Reproductive health
Non-Government Organisation	1	Health promotion and adolescent health
	1	Health promotion and reproductive health
Chi Linh hospital	1	Reproductive health
Chi Linh intervention deliverers	1	Health promotion, reproductive health and adolescent health
Chi Linh intervention – high school	1	Adolescent health

Fourteen experts with backgrounds and experience in health promotion and/or reproductive health among adolescents were interviewed. These experts' working positions enabled them to understand the real situation of adolescent reproductive health.

The findings from the expert elicitation towards the effectiveness of the education intervention in Chi Linh are illustrated in Tables 15 and 16.

Table 15: Results from expert elicitation on effectiveness of the education intervention

Questions	Comparators	Relative risk (Mean)	SD of logRR
What is your belief of the incidences of becoming sexually active adolescents among adolescents (%) within the last 3 months?	Male, B vs. A	0.8722	0.1313
	Male, C vs. A	0.8296	0.1332
	Female, B vs. A	0.8764	0.1502
	Female, C vs. A	0.8103	0.1536
What is your belief of the rate of having premarital sexual intercourses among adolescents (%) at 6/2013?	Male, B vs. A	0.9400	0.0429
	Male, C vs. A	0.9340	0.0430
	Female, B vs. A	0.9630	0.0531
	Female, C vs. A	0.9590	0.0532
What is your belief of the rate of using condoms among sexually active adolescents (%) in their previous sexual intercourse?	Male, B vs. A	1.4431	0.0305
	Male, C vs. A	1.5637	0.0297
	Female, B vs. A	1.4778	0.0344
	Female, C vs. A	1.6893	0.0330
What is your belief of the rate of using condom properly among sexually active adolescents (%) at their previous sexual intercourse?	Male, B vs. A	1.4425	0.0254
	Male, C vs. A	1.6015	0.0244
	Female, B vs. A	1.4560	0.0265
	Female, C vs. A	1.6282	0.0254

Results from expert elicitation illustrated in Table 15 were used for the calculation of different transition probabilities, for example the probability of contracting HIV infection or other STDs among sexually active adolescents in Chi Linh and the probability of becoming pregnant among sexually active adolescents (5.3.2 – transition probabilities)

Table 16: Results from expert elicitation on effectiveness of the education intervention

Questions	Subject	Mean	SD
What is your belief of the average number of sexual intercourses within the last 3 months among sexually active adolescents?	Male, Intervention A	12.0	1.4084
	Male, Intervention B	11.4	1.4241
	Male, Intervention C	11.3	1.4329
	Female, Intervention A	11.8	0.9376
	Female, Intervention B	11.7	0.9606
	Female, Intervention C	11.1	1.0159
What is your belief of the average number of partners per sexually active adolescent within the last 3 months?	Male, Intervention A	1.74	0.077
	Male, Intervention B	1.54	0.073
	Male, Intervention C	1.42	0.070
	Female, Intervention A	1.43	0.055
	Female, Intervention B	1.30	0.050
	Female, Intervention C	1.23	0.510

Results from expert elicitation illustrated in Table 16 were used for the calculation of probability of becoming sexually active among the adolescents and also the calculation of different transition probabilities, for example the probability of becoming infected with HIV or other STDs among sexually active adolescents in Chi Linh (see 5.3.2 – transition probabilities).

6.6. Summary

The aim of this chapter was to estimate input parameters of the model that were at high level of evidence and suitable to use within the economic evaluation in the Vietnamese context. Different methods and instruments used to collect different types of information were carefully explained. Those primary data greatly assisted the economic evaluation. First, the estimation of cost incurred by intervention participants and cost incurred by health care patients and families were used to calculate the intervention costs and the health care costs for different health states in the decision model. Second, the descriptions for each health state of interest from the perspective of adolescents in Chi Linh were used for the calculation of disutility, and subsequently, utility scores (health related quality of life). The strength of the data collection method was that all of the health state descriptions were from the point of view of primary participants of the reproductive health education intervention, therefore, the utility scores related to each health state were suitable for the decision model. Finally, the likely effectiveness of the educational intervention was measured using the prior elicitation technique: “structured questionnaires and pooling of opinion”. This method was suitable for circumstances where direct evaluation of intervention outcomes were not available. Results from the expert elicitation were used to calculate both the baseline transition probabilities and the “with intervention, B or C” transition probabilities.

Chapter 7 - Results: Cost-effectiveness of the intervention

In this chapter, the results of the deterministic analysis in terms of the incremental costs, incremental health benefits and incremental cost-utility ratios of the education interventions are presented (7.1). Next, the results of the probabilistic sensitivity analysis quantifying the uncertainty of input parameters surrounding the decision are illustrated (7.2). This is followed by the results of the scenario analysis dealing with the uncertainty of the interventions' effectiveness parameters only (7.3). The expected value of perfect information with regard to whether the collection of additional evidence can be justified to support decision making is then evaluated (7.4). This chapter concludes with a summary of findings.

7.1. Deterministic analysis

The analysis is based on a cohort of 100,000 adolescents, equally divided into two groups of males and females. Table 17 gives an overview of model outcomes for each health state of interest in the last cycle of the model. The table shows that the model was structured identically for adolescents at intervention levels A, B and C, but those at levels B and C were assigned a lower probability of getting diseases related to reproductive health. Similarly, the model was structured identically for males and females at three interventions, but the probabilities of male getting several health states, such as abortion, post abortion/delivery were set zero.

A summary of the total costs and health benefits of the interventions for male and female adolescents is presented in tables 10, 11 and 13. The total costs are presented from the two costing scenarios: the Ford Foundation and the Vietnam Government cost-norm. The total health benefits are expressed as number of quality adjusted life years (QALYs).

Table 17: Number of adolescents in each health state of interest

Health states in the model	Male (cycle = 55)			Female (cycle = 40)		
	Level A	Level B	Level C	Level A	Level B	Level C
Healthy	49,863.5	49,898.5	49,910.9	49,695.8	49,753.2	49,783.1
Abortion	0.0	0.0	0.0	1.3	1.1	1.0
Giving birth	0.0	0.0	0.0	1.5	1.2	1.1
Post-abortion/delivery	0.0	0.0	0.0	15.4	12.7	11.5
HIV (Asymptomatic or Untreated)	0.8	0.6	0.5	2.0	1.6	1.3
HIV (Treated)	9.7	6.7	5.7	16.6	13.0	10.7
Gonorrhea (Asymptomatic or Untreated)	15.5	10.9	9.2	63.6	51.2	44.9
Chlamydia (Asymptomatic or Untreated)	22.9	16.1	13.7	82.0	66.1	58.0
Acute STDs (treated)	57.6	40.5	34.5	65.5	52.8	46.3
PID	11.0	7.7	6.6	47.7	38.5	33.7
RH problem mortality	2.0	0.2	0.1	0.4	0.3	0.2
Other-causes mortality	18.8	18.8	18.8	8.3	8.3	8.3
Total	50,000	50,000	50,000	50,000	50,000	50,000

7.1.1. Using the Ford Foundation cost-norm

Compared to “no education intervention – level A”, implementation of education intervention level B for either males or females or a group of both male and female participants was cost-effective. Intervention level B for male students would increase costs by AUD4,772 per QALY gained, that intervention for female students would increase costs by only AUD2,988 per QALY gained, and that intervention for a group of both male and female students would increase costs by AUD3,727 per QALY gained compared to intervention level A.

Compared to intervention level A, implementation of education intervention level C was only cost-effective for female participants and the group of both male and female participants, but not cost-effective for male participants. Intervention level C for male students would increase costs by AUD5,743 per QALY gained, that intervention for female students would increase costs by only AUD3,106 per QALY gained, and that intervention for both male and female students would increase costs by only AUD4,120 per QALY gained compared to intervention level A.

Compared to intervention level B, implementation of education intervention level C was only cost-effective for females and the group of both male and female participants, but not cost-effective for male participants. Intervention level C over level B for male students would increase costs by AUD8,521 per QALY gained, that intervention for female students would increase costs by only AUD3,332 per QALY gained, and that intervention for both male and female students would increase costs by only AUD4,995 per QALY gained.

Table 18: Results of the deterministic analysis for males, females and both males and females using the Ford Foundation cost-norm

Male	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	**Different (C-B)**
Total cost (in AUD)	263,982	513,345	673,086	249,363	409,103	159,740
Total cost (discounted) (in AUD)	212,484	477,434	642,579	264,949	430,094	165,146
QALYs	646,932	647,000	647,024	68.08	91.84	23.76
QALYs (discounted)	533,578	533,634	533,652	55.51	74.89	19.38
ICER				4,772	5,743	8,521
Cost-Effective?				**Yes**	**Not**	**Not**
Female	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	**Different (C-B)**
Total cost (in AUD)	559,429	778,673	907,126	219,243	347,696	128,453
Total cost (discounted) (in AUD)	479,337	714,357	851,374	235,020	372,036	137,016
QALYs	470,286	470,377	470,425	91.25	138.99	47.75
QALYs (discounted)	408,662	408,741	408,782	78.65	119.77	41.12
ICER				2,988	3,106	3,332
Cost-Effective?				**Yes**	**Yes**	**Yes**
Male & Female	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	**Different (C-B)**
Total cost (in AUD)	823,412	1,292,018	1,580,211	468,606	756,799	288,193
Total cost (discounted) (in AUD)	691,822	1,191,791	1,493,953	499,969	802,131	302,162
QALYs	1,117,218	1,117,378	1,117,449	159.32	230.83	71.51
QALYs (discounted)	942,240	942,374	942,435	134.16	194.66	60.50
ICER				3,727	4,120	4,995
Cost-Effective?				**Yes**	**Yes**	**Yes**

Figures 8 and 9 show the results of deterministic analysis on the incremental cost-effectiveness plane with the incremental cost-effectiveness threshold shown as the straight line at a value of AUD5,265 per QALY gained (World Health Organization).

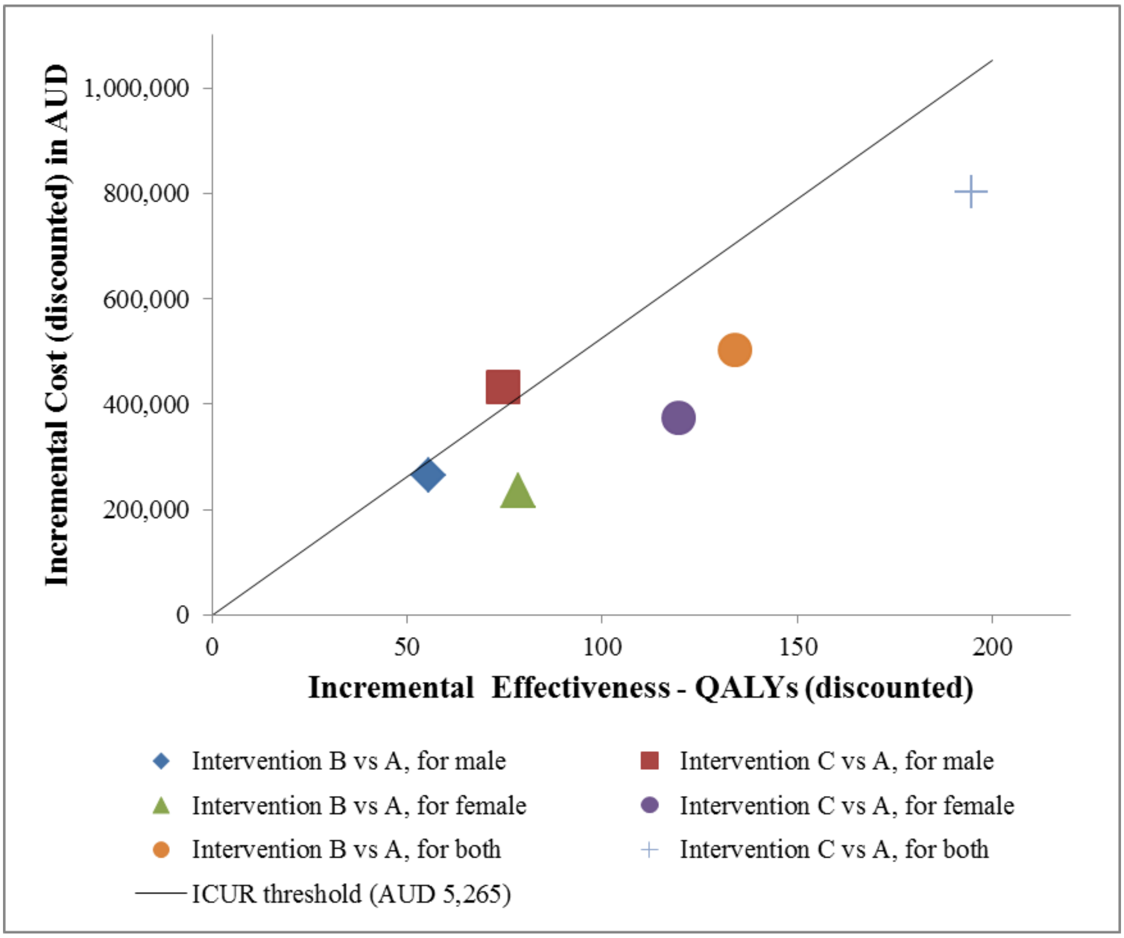


Figure 8: Incremental cost-utility ratio of alternative interventions compared to A – using the Ford Foundation cost norm.

All the ICERs of intervention B and C compared to intervention A for female participants and both male and female participants and the ICER of intervention B compared to intervention A for male participants lie under the ICER threshold line, showing that they were all cost-effective. Only the ICER of intervention C compared to intervention A for male participants lies above the ICER threshold line, showing that it was not cost-effective.

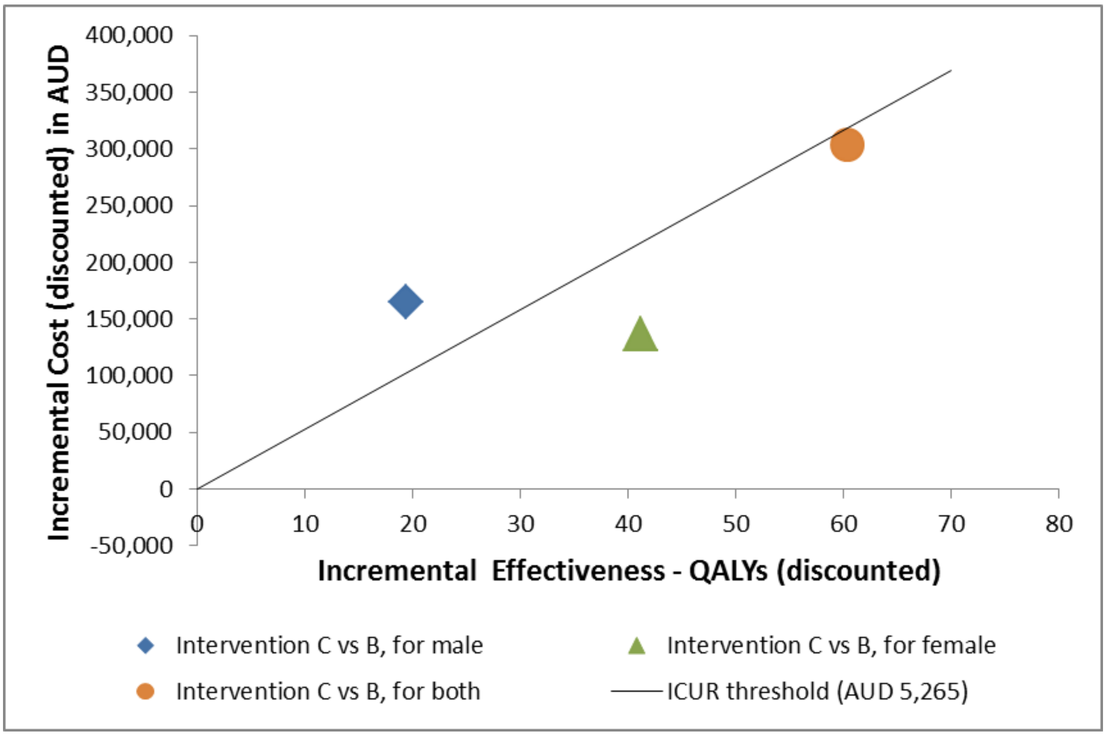


Figure 9: Incremental cost-utility ratio of intervention C compared to B – using the Ford Foundation cost norm

The ICERs of intervention C compared to intervention B for female participants and the group of both male and female participants lie under the ICER threshold line, showing that they were all cost-effective. Only the ICER of intervention C compared to intervention B for male participants lies above the ICER threshold line, showing that it was not cost-effective.

7.1.2. Using the Vietnam Government cost-norm

Compared to “no education intervention – level A”, implementation of education intervention level B for either male group or female group or a group of both male and female participants was highly cost-effective as they were less than one time GDP per head in Vietnam. Intervention level B for male students would increase costs by AUD1,375 per QALY gained, that intervention for female students would increase costs by as low as AUD590 per QALY gained and that intervention for both male and female students would increase costs by AUD915 per QALY gained compared to intervention level A.

Compared to intervention level A, implementation of education intervention level C was highly cost-effective for either female group or both male and female group and was cost-effective for male participants. Intervention level C for male students would increase costs by AUD1,979 per QALY gained, that intervention for female students would increase costs by only AUD753 per QALY gained and that intervention for both male and female students would increase costs by only AUD1,224 per QALY gained compared to intervention level A.

Compared to intervention level B, implementation of education intervention level C was cost-effective for male group and the group of both male and female participants, was highly cost-effective for female participants. Intervention level C over level B for male students would increase costs by AUD 3,708 per QALY gained, that intervention for female students would increase costs by as low as AUD1,064 per QALY gained, and that intervention for both male and female students would increase costs by only AUD1,911 per QALY gained.

Table 19: Results of the deterministic analysis for males, females and both males and females using the Vietnam Government cost-norm

Male	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	**Different (C-B)**
Total cost (in AUD)	263,983	324,730	391,194	60,748	127,211	66,463
Total cost (discounted) (in AUD)	212,485	288,819	360,688	76,334	148,203	71,868
QALYs	646,932	647,000	647,024	68.08	91.84	23.76
QALYs (discounted)	533,578	533,633	533,653	55.51	74.89	19.38
ICER				1,375	1,979	3,708
Cost-Effective?				**Highly**	**Yes**	**Yes**
Female	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	Different (C-B)
Total cost (in AUD)	559,429	590,058	625,234	30,629	65,805	35,176
Total cost (discounted) (in AUD)	479,337	525,743	569,482	46,405	90,144	43,739
QALYs	470,286	470,377	470,425	91.25	138.99	47.75
QALYs (discounted)	408,662	408,741	408,782	78.65	119.77	41.12
ICER				590	753	1,064
Cost-Effective?				**Highly**	**Highly**	**Highly**
Male & Female	**Intervention A**	**Intervention B**	**Intervention C**	**Different (B-A)**	**Different (C-A)**	**Different (C-B)**
Total cost (in AUD)	823,412	914,788	1,016,428	91,377	193,016	101,639
Total cost (discounted) (in AUD)	691,822	814,561	930,169	122,739	238,347	115,607
QALYs	1,117,218	1,117,377	1,117,449	159.32	230.83	71.51
QALYs (discounted)	942,240	942,374	942,435	134.16	194.66	60.50
ICER				915	1,224	1,911
Cost-Effective?				**Highly**	**Highly**	**Yes**

Figures 10 and 11 show the results of deterministic analysis on the incremental cost-effectiveness plane with the incremental cost-effectiveness threshold shown as the straight line at a value of AUD5,265 per QALY gained (World Health Organization).

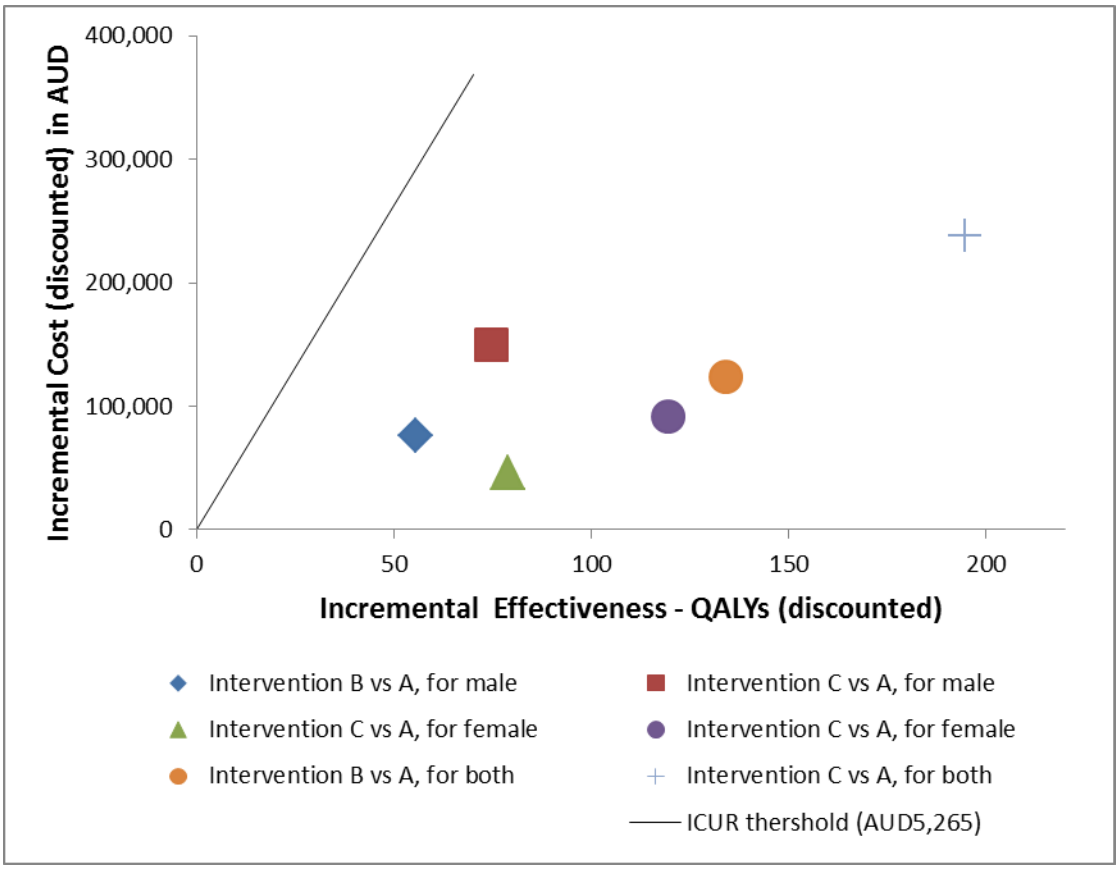


Figure 10: Incremental cost-utility ratio of alternative interventions compared to A – using the Vietnam Government cost norm

All the ICERs of intervention B and C compared to intervention A for male group, female group and both male and female group lie under the ICER threshold line, showing that they were all cost-effective.

The ICERs of intervention C compared to intervention B for male only, female only and the group of both male and female participants lie under the ICER threshold line, showing that they were all cost-effective.

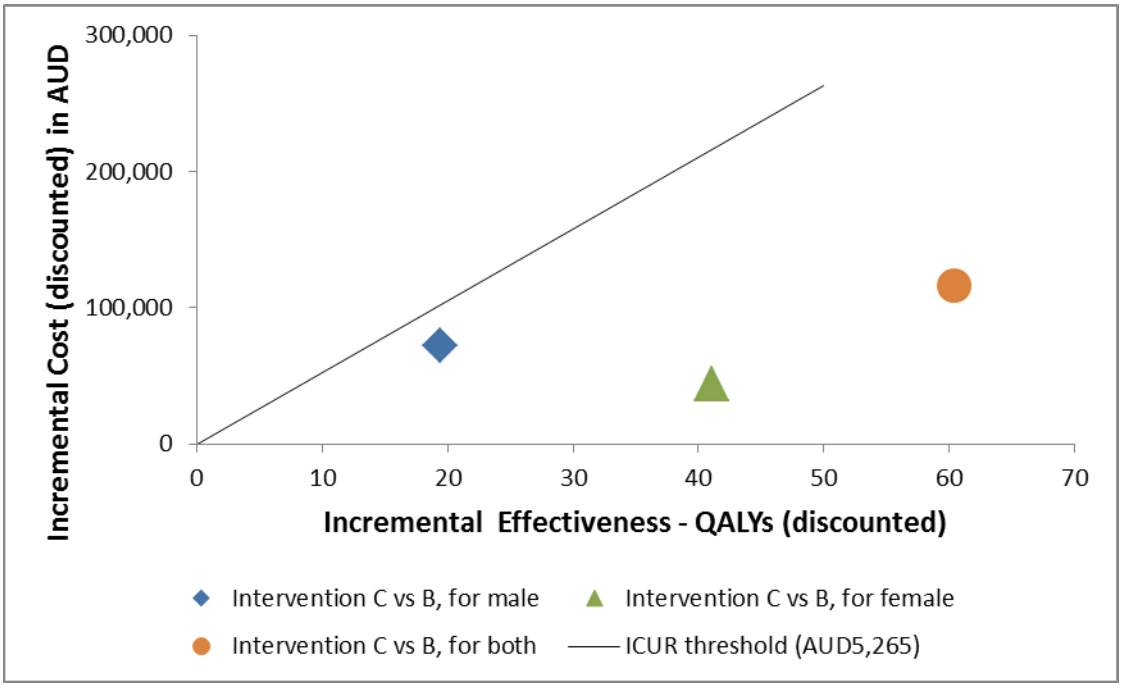


Figure 11: Incremental cost-utility ratio of intervention C compared to B – using the Vietnam Government cost norm

7.2. Probabilistic sensitivity analysis

The probabilistic sensitivity analysis results capture uncertainty of model input parameters. In this section, the results from 1,000 simulations are described. The results of probabilistic sensitivity analysis of the alternative interventions (intervention B and C) in relation to the control (intervention A) are illustrated as the scatter plots on the incremental cost-effectiveness plane (7.2.1 and 7.2.4), then the results of probabilistic sensitivity analysis of intervention C in relation to the next best intervention (intervention B) are illustrated as the scatter plots on the incremental cost-effectiveness plane (7.2.2 and 7.2.5). Finally, in order to determine the optimal choice, the results of probabilistic sensitivity analysis are plotted as cost-effectiveness acceptability frontiers (7.2.3 and 7.2.6).

7.2.1. Probabilistic sensitivity analysis for intervention B compared to A - Using the Ford Foundation cost-norm

Figures 12 – 14 show the results of probabilistic analysis for intervention level B compared to A, for male participants, females participants, and both males and females respectively. The green triangle in each plot indicates the deterministic point result and the straight line illustrates the incremental cost-utility threshold in Vietnamese context.

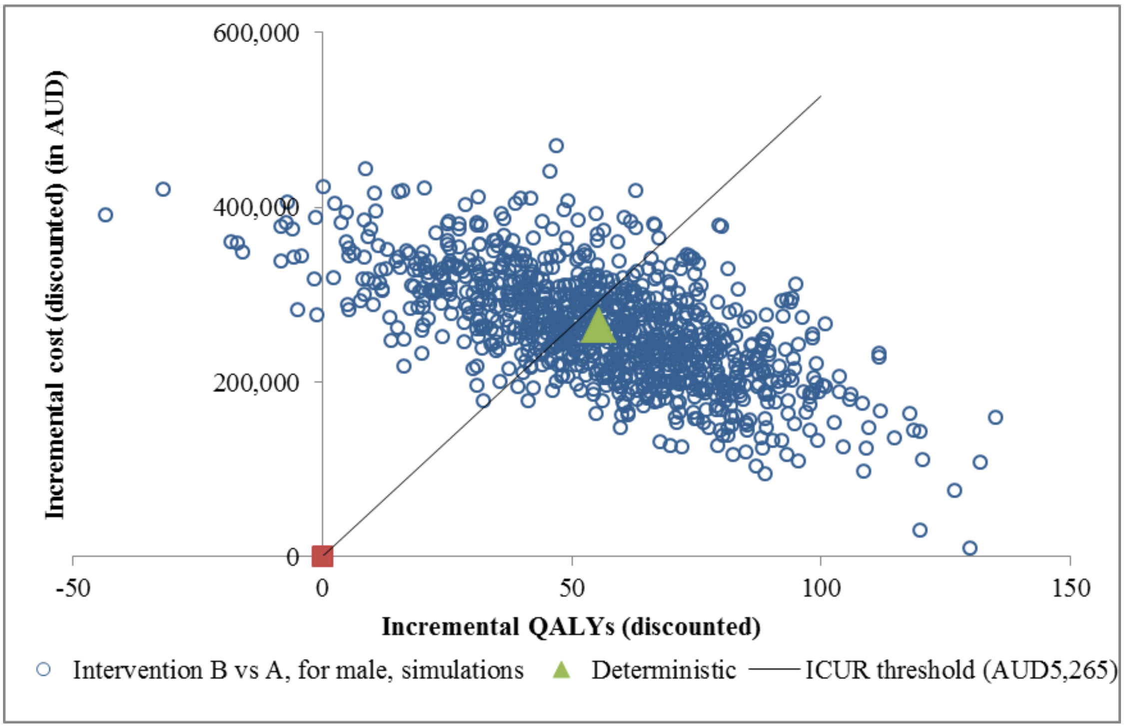


Figure 12: Probabilistic results for intervention B vs. A for males on Incremental CE plane – the Ford Foundation cost norm

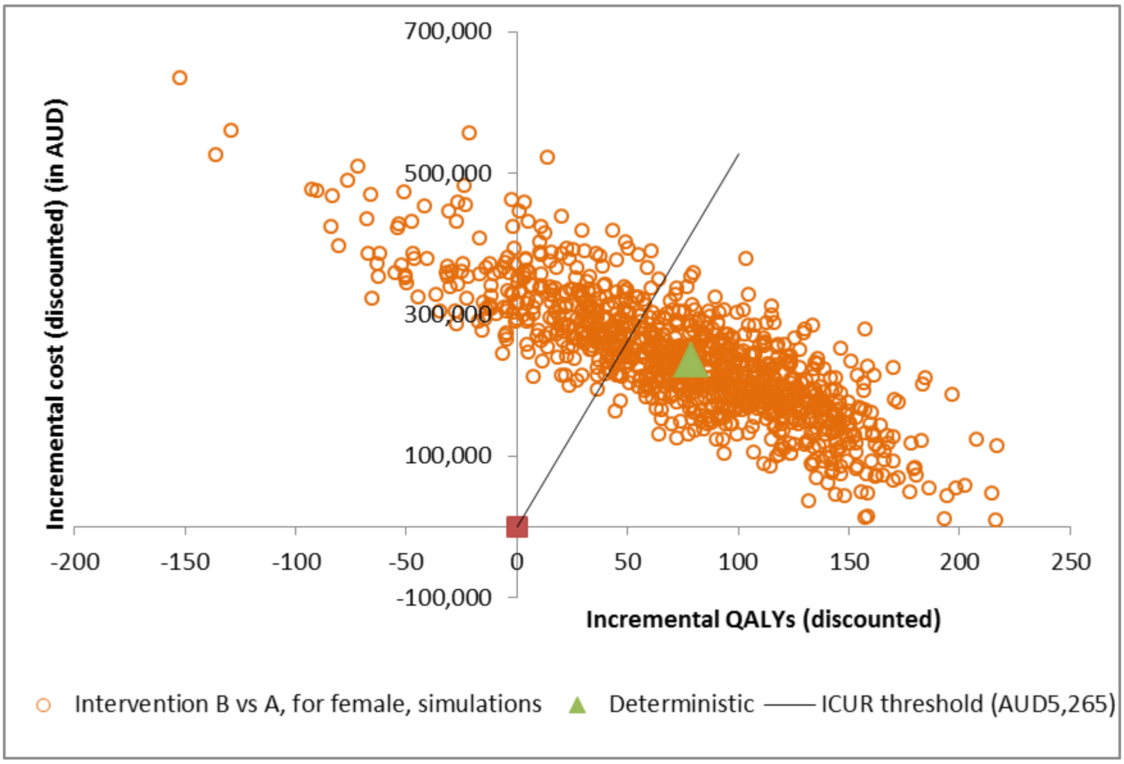


Figure 13: Probabilistic results for intervention B vs. A for females on Incremental CE plane – the Ford Foundation cost norm

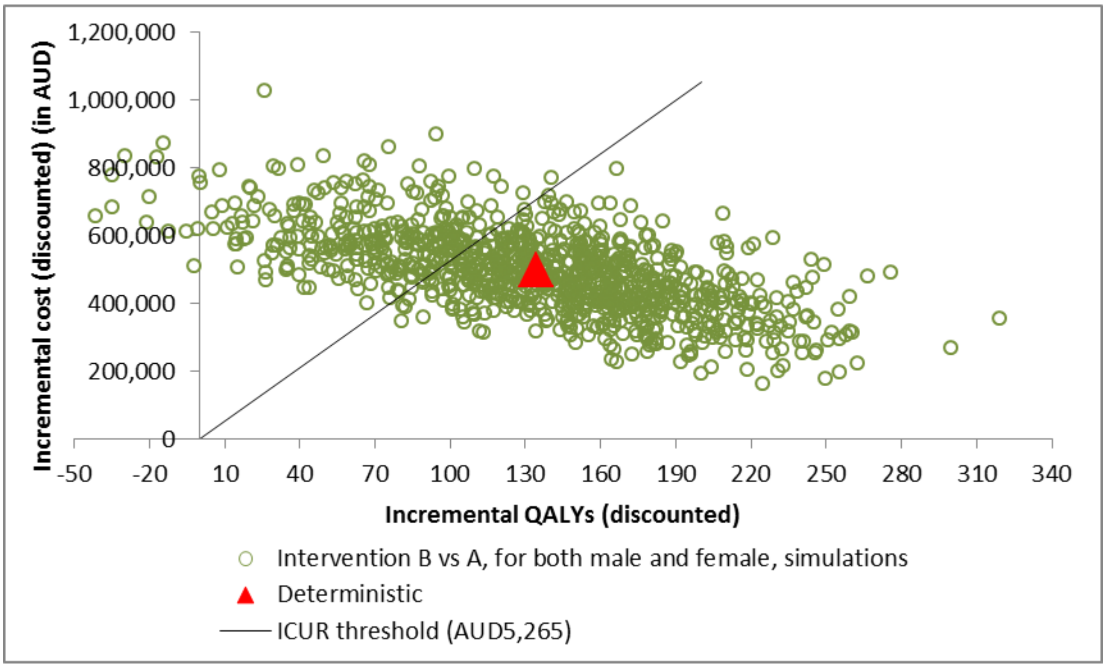


Figure 14: Probabilistic results for intervention B vs. A for both males and females on Incremental CE plane – using the Ford Foundation cost norm

At the ceiling ratio of λ = AUD5,265, there was a chance of 59.4%, 69.2%, 70.5% that intervention B for males, females and a group of both males and females, respectively, was cost-effective compared with intervention A.

The net monetary benefit (NMB) for the different interventions was calculated using the willingness-to-pay ratio of AUD5,265. The NMB and the incremental NMB are reported along with their 95% credible intervals in Table 20 for a cohort of 50,000 males and 50,000 females.

At an cost-utility ratio threshold of AUD 5,265/QALY, implementation of intervention level B for male participants and level C for female participants were the most beneficial options with the highest values of mean of NMB. However, for both male and female participants, implementation of intervention level C was the most beneficial option with the highest value of mean of NMB compared with level A. The overall expected incremental NMB achieved by the intervention was AUD34,422 (level B, for males), AUD240,969 (level C for females) and AUD201,429 (level C for both male and female participants). The only negative mean incremental NMB was for male participants in intervention level C, illustrating the only intervention that was not beneficial for adolescents. The 95% credible intervals of the NMB for males or females or both males and females did not span zero, indicating the certainty surrounding the decision.

Table 20: NMB of different levels of education interventions at a ICER threshold of AUD5,265/QALYs (the Ford Foundation cost norm)

Cost norm from Ford Foundation	Total NMB (in AUD)		Incremental NMB (in AUD)	
	Mean	95% credible interval*	Mean	95% credible interval
Male – intervention A	2,809,671,057	(2,809,404,501; 2,809,937,614)	Comparator	
Male – intervention B	2,809,705,479	(2,809,438,484; 2,809,972,475)	34,422	(23,545; 45,300)
Male – intervention C	2,809,631,517	(2,809,364,212; 2,809,898,822)	-39,540	(-49,818; -29,263)
Female – intervention A	2,151,579,071	(2,151,374,906; 2,151,783,236)	Comparator	
Female – intervention B	2,151,740,604	(2,151,535,535; 2,151,945,673)	161,533	(139,052; 184,014)
Female – intervention C	2,151,820,040	(2,151,615,317; 2,152,024,763)	240,969	(221,143; 260,795)
Male & Female – intervention A	4,961,250,128	(4,960, 779,498; 4,961,720,758)	Comparator	
Male & Female – intervention B	4,961,446,083	(4,960,974,739; 4,961,917,428)	195,955	(170,974; 220,937)
Male & Female – intervention C	4,961,451,557	(4,960,980,055; 4,961,923,059)	201,429	(178,374; 224,484)

** As the decision analytic model was developed within the Bayesian framework, "credible intervals" were reported instead of "confidence intervals*

7.2.2. Probabilistic sensitivity analysis for intervention C compared to B - Using the Ford Foundation cost-norm

Figures 15 - 17 show the results of probabilistic analysis for intervention for male group, female group and for both male and female group, respectively, level C compared to B.

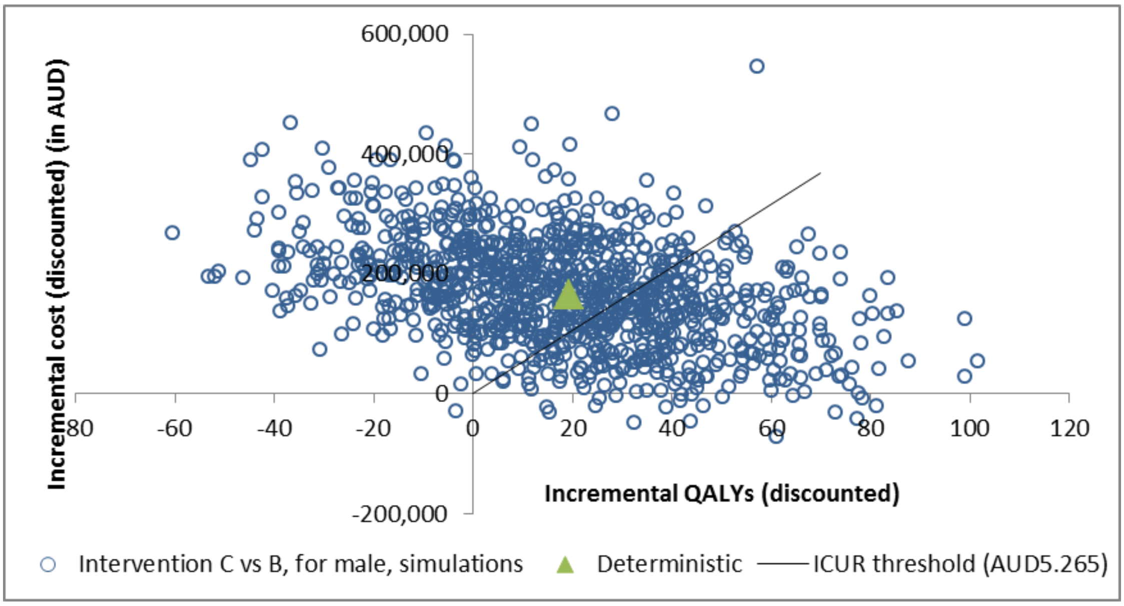


Figure 15: Probabilistic results for intervention C vs. B for males on Incremental CE plane – the Ford Foundation cost norm

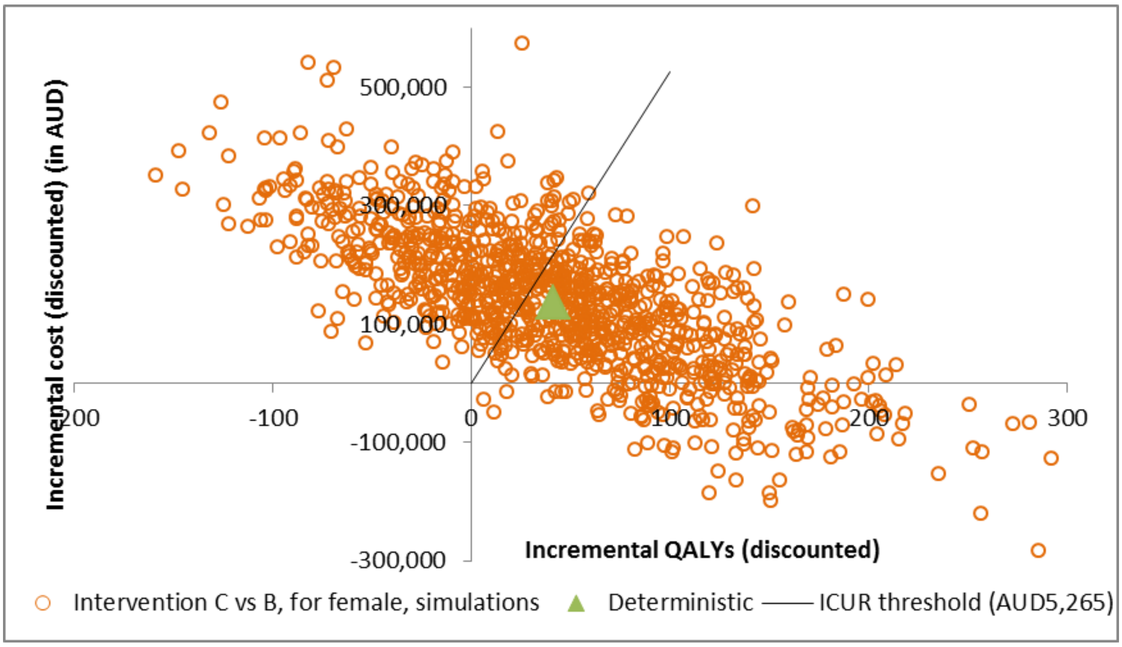


Figure 16: Probabilistic results for intervention C vs. B for females on Incremental CE plane – the Ford Foundation cost norm

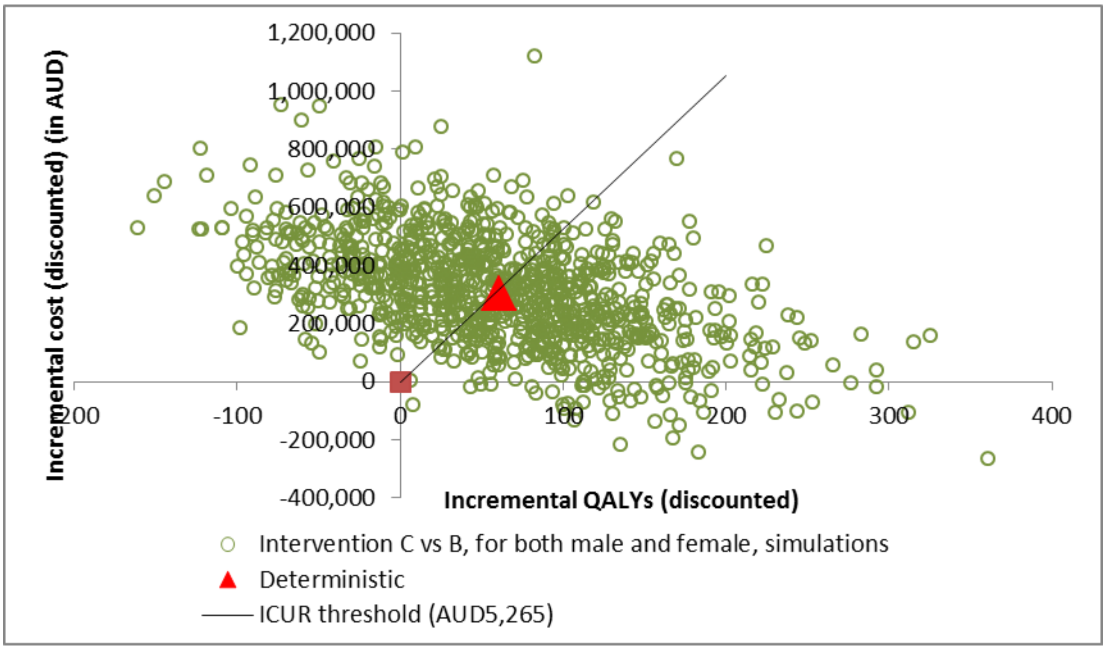


Figure 17: Probabilistic results for intervention C vs. B for both males and females on Incremental CE plane – the Ford Foundation cost norm

These above figures show that at the ceiling ratio of λ = AUD 5,265, there was a chance of 36.5%, 55.0% and 50.7% that intervention C for males, females and a group of both males and females, respectively, was cost-effective compared with intervention B.

The net monetary benefit (NMB) for the different interventions was calculated using the willingness-to-pay ratio of AUD5,265. The NMB and the incremental NMB are reported along with their 95% credible intervals in Table 21 for a cohort of 50,000 males and 50,000 females.

Compared to intervention level B, implementation of intervention level C for female participants was a beneficial option with the value of overall expected incremental NMB higher than zero (AUD79,436). However, for male participants, implementation of intervention level C was not a beneficial option as the overall expected incremental NMB lower than zero (AUD -73,963). The 95% credible intervals of the NMB for males or females did not span zero value, indicating the certainty surrounding the decision.

For both male and female participants, implementation of intervention level C over B was a beneficial option with the value of overall expected incremental NMB higher than zero (AUD5,473), but the 95% credible intervals of the NMB did span zero value, indicating the uncertainty surrounding the decision.

Table 21: NMB of different levels of education interventions at a ICER threshold of AUD5,265/QALYs (the Vietnam Government cost norm)

Cost norm from Ford Foundation	**Total NMB (in AUD)**		**Incremental NMB (in AUD)**	
	Mean	**95% credible interval***	**Mean**	**95% credible interval**
Male – intervention B	2,809,705,479	(2,809,438,484; 2,809,972,475)	Comparator	
Male – intervention C	2,809,631,517	(2,809,364,212; 2,809,898,822)	-73,963	(-86,070; -61,856)
Female – intervention B	2,151,740,604	(2,151,535,535; 2,151,945,673)	Comparator	
Female – intervention C	2,151,820,040	(2,151,615,317; 2,152,024,763)	79,436	(50,576; 108,297)
Male & Female – intervention B	4,961,446,083	(4,960,974,739; 4,961,917,428)	Comparator	
Male & Female – intervention C	4,961,451,557	(4,960,980,055; 4,961,923,059)	5,473	(-26,659; 37,605)

** As the decision analytic model was developed within the Bayesian framework, "credible intervals" were reported instead of "confidence intervals"*

7.2.3. Optimal cost-effectiveness decision – Using the Ford Foundation cost-norm

Figures 18 - 20 show the Cost-Effectiveness Acceptability Frontiers (CEAFs) for different education intervention levels for males only, females only, and for both male and female participants, respectively. The CEAF plots only the probability that the optimal option is cost-effective at different values of ceiling ratio, λ.

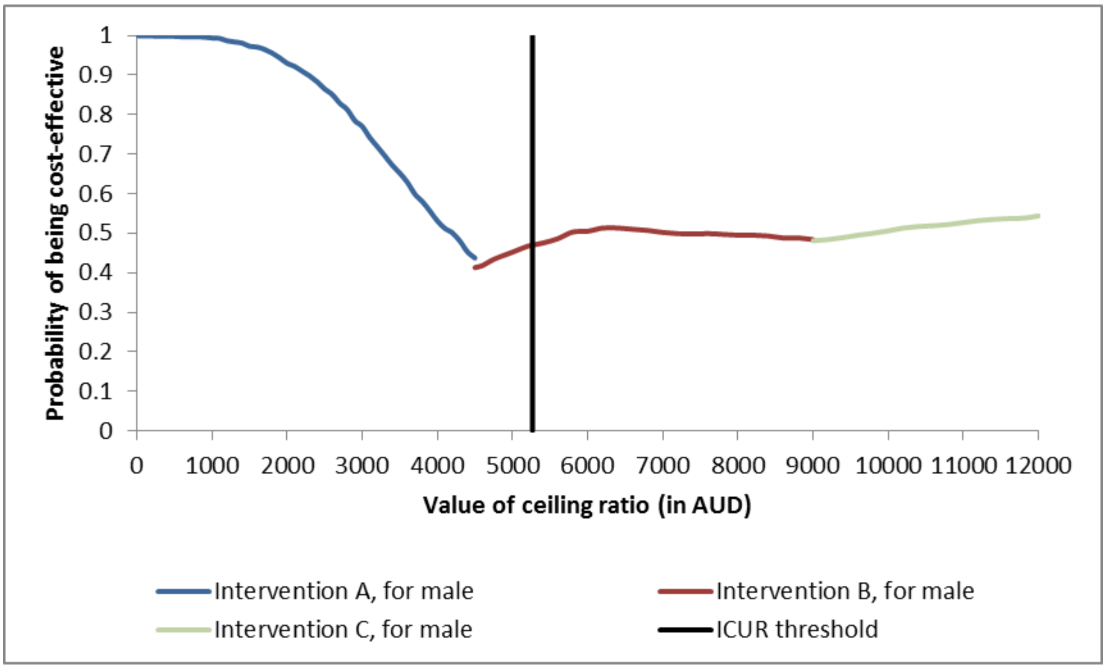


Figure 18: CEAF of different education intervention levels for males at different values of ICER threshold – the Ford Foundation cost norm

For male, intervention level A would be the optimal choice if the willingness to pay threshold was in the range between AUD0 and AUD4,500. When the willingness to pay fell in the range between AUD4,500 and AUD9,000, the optimal choice would be intervention level B. When the willingness to pay was higher than AUD9,000, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level B had the highest probability of being cost-effective.

For female, intervention level A would be the optimal choice if the willingness to pay threshold was in the range between AUD0 and AUD2,500. When the willingness to pay fell in the range between AUD2,500 and AUD3,900, the optimal choice would be intervention level B. When the willingness to pay was higher than AUD3,900, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level C had the highest probability of being cost-effective.

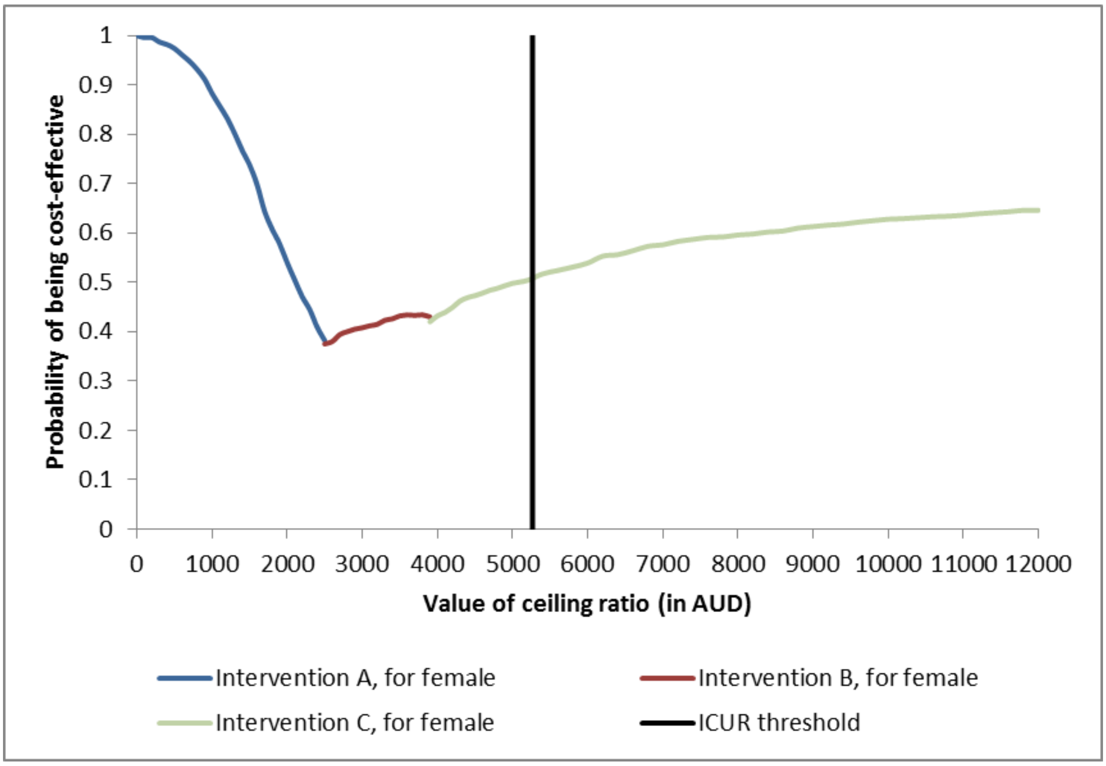


Figure 19: CEAF of different education intervention levels for females at different values of ICER threshold – the Ford Foundation cost norm.

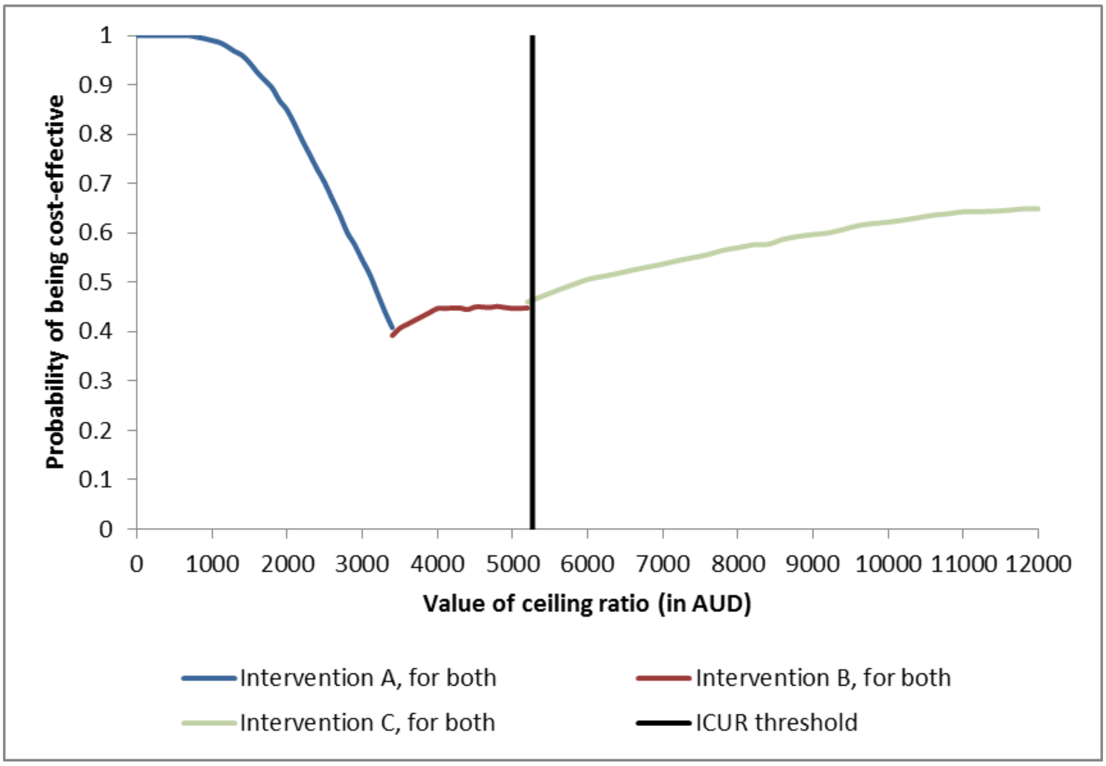


Figure 20: CEAF of different education intervention levels for males and females at different values of ICER threshold – the Ford Foundation cost norm

For a group of both male and female, intervention level A would be the optimal choice if the willingness to pay threshold was in the range between AUD0 and AUD3,400. When the willingness to pay fell in the range between AUD3,400 and AUD5,200, the optimal choice would be intervention level B. When the willingness to pay was higher than AUD5,200, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level C had the highest probability of being cost-effective.

7.2.4. Probabilistic sensitivity analysis for intervention B compared to A - Using the Vietnam Government cost-norm

Figures 21 - 22 show the results of probabilistic analysis for interventions level B compared to A, for males, females and both males and females, respectively. The green triangle in each plot indicates the deterministic point result and the straight line illustrates the ICER threshold in Vietnamese context.

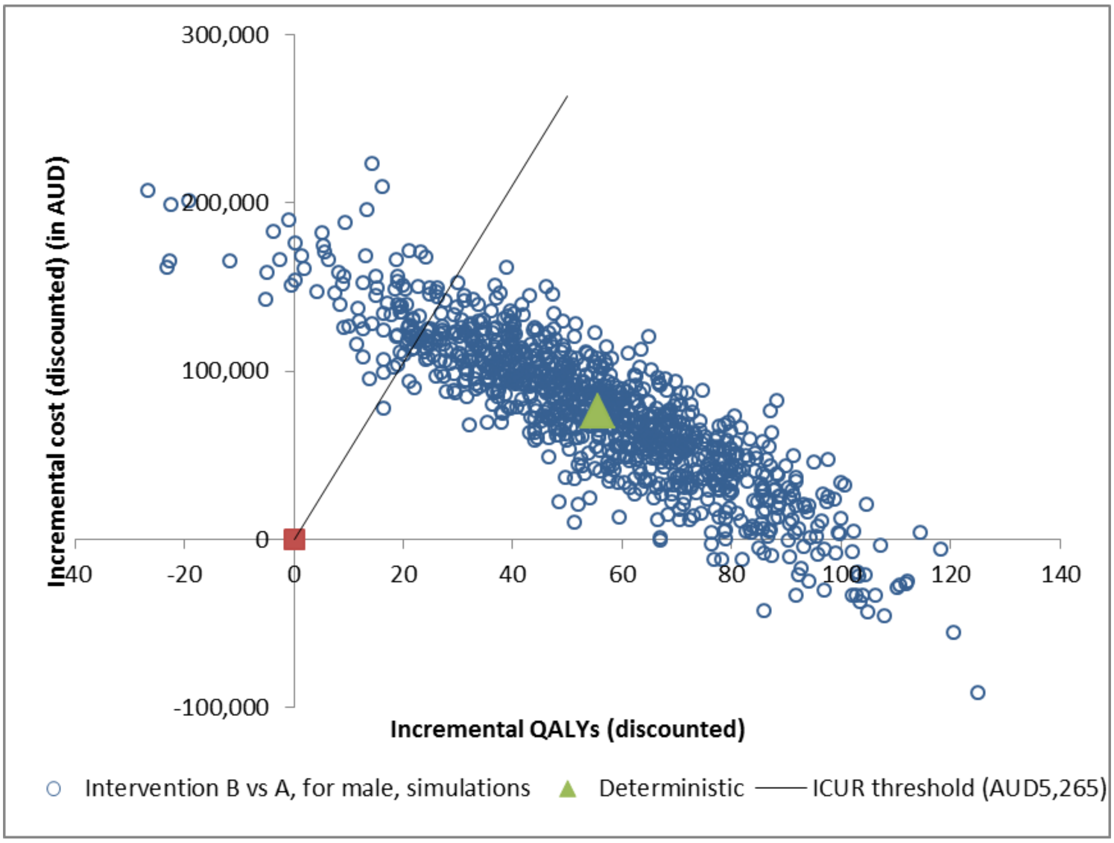


Figure 21: Probabilistic results for intervention B vs. A for males on Incremental CE plane – the Vietnam Government cost norm

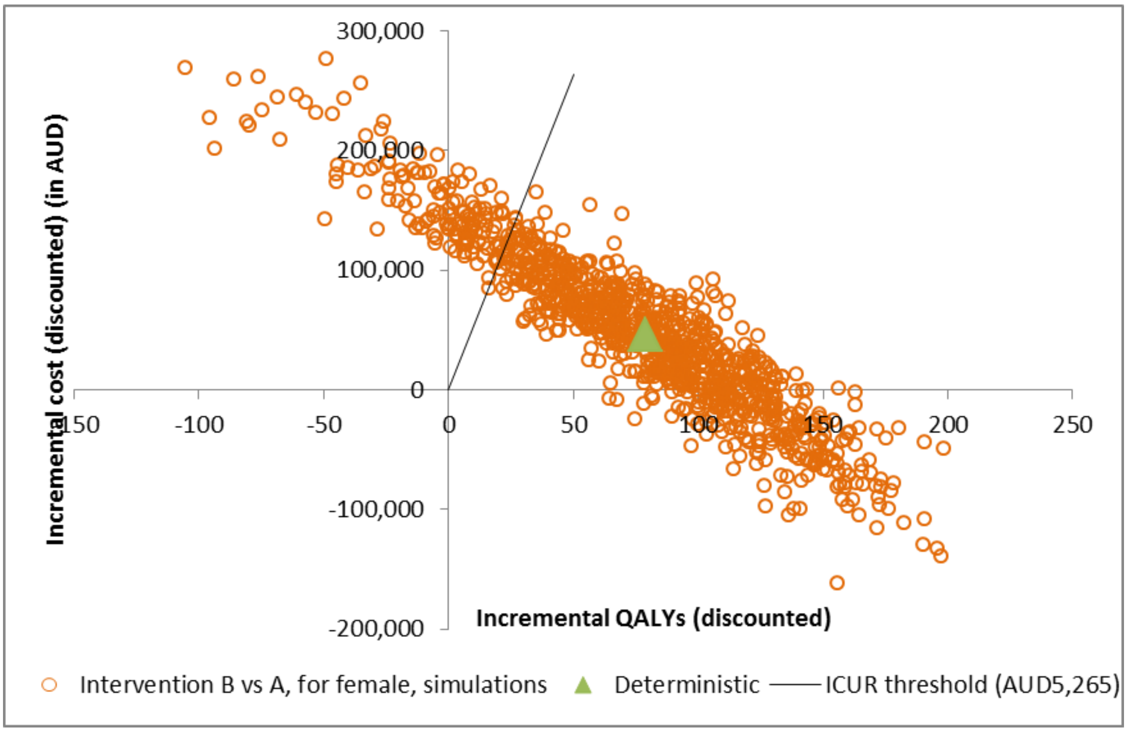


Figure 22: Probabilistic results for intervention B vs. A for females on Incremental CE plane – the Vietnam Government cost norm

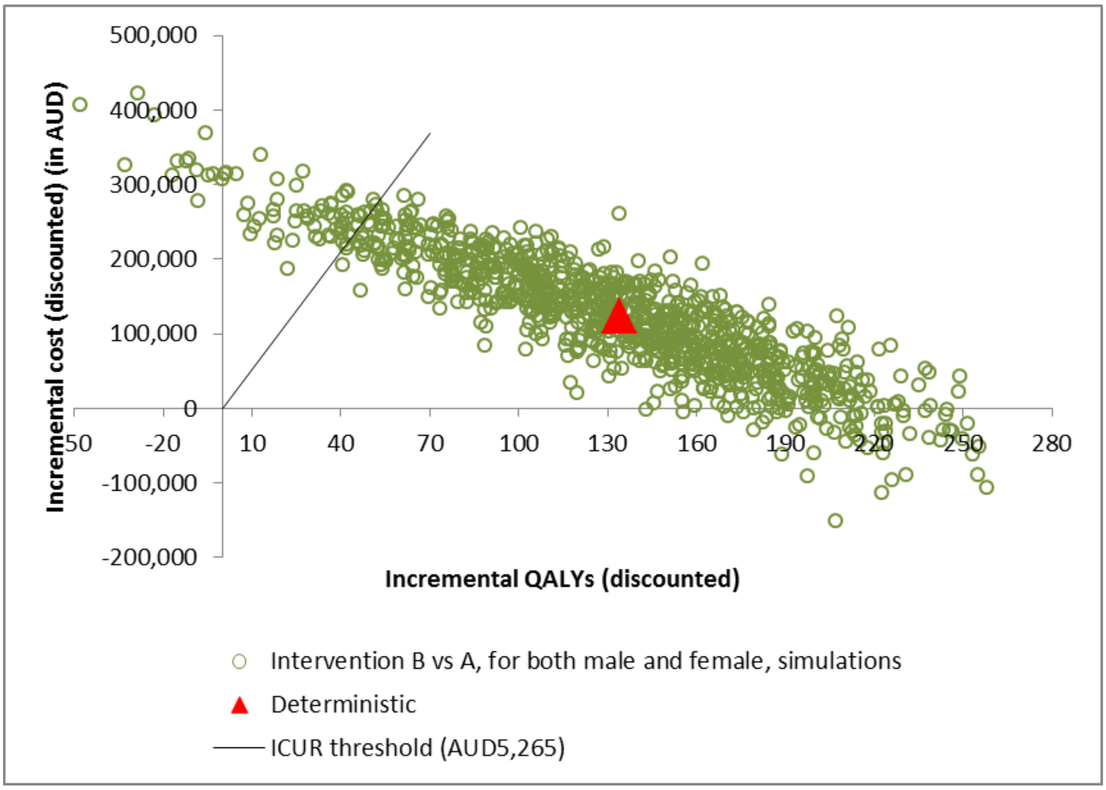


Figure 23: Probabilistic results for intervention B vs. A for both males and females on Incremental CE plane – the Vietnam Government cost norm

These above figures show that at the ceiling ratio of λ = AUD5,265, there was a chance of 90.8%, 85.8% and 93.0% that intervention B for males, females and a group of both males and females, respectively, was cost-effective compared with intervention A.

The net monetary benefit (NMB) for the different interventions was calculated using the willingness-to-pay ratio of AUD5,265. The NMB and the incremental NMB are reported along with their 95% credible intervals in Table 22 for cohorts of 50,000 males, 50,000 females and a cohort of 100,000 males and females.

At an incremental cost-utility ratio threshold of AUD5,265/QALY, implementation of intervention level C for either male or female participants was the most beneficial options with the highest values of mean of NMB. Consequently, for both male and female participants, implementation of intervention level C was the most beneficial option with the highest value of mean of NMB compared with levels A and B.

The overall expected incremental NMB achieved by the intervention was AUD242,437 (level C, for males), AUD511,441 (level C for females) and AUD753,878 (level C for both male and female participants). There was no negative mean incremental NMB for intervention levels B or C compared with A for either male or female participants, illustrating all level of education interventions (B or C) were beneficial for adolescents. The 95% credible intervals of the NMB for males or females or both males and females did not span zero value, indicating the certainty surrounding the decision.

Table 22: NMB of different levels of education interventions at a ICER threshold of AUD5,265/QALYs (the Vietnam Government cost norm)

Cost norm from Ford Foundation	Total NMB		Incremental NMB	
	Mean	95% credible interval*	Mean	95% credible interval
Male – intervention A	2,809,516,156	(2,809,241,691; 2,809,790,622)	Comparator	
Male – intervention B	2,809,728,967	(2,809,454,105; 2,810,003,828)	212,810	(202,722; 222,899)
Male – intervention C	2,809,758,593	(2,809,483,655; 2,810,033,531)	242,437	(232,640; 252,233)
Female – intervention A	2,151,466,657	(2,151,256,810; 2,151,676,503)	Comparator	
Female – intervention B	2,151,819,840	(2,151,608,731; 2,152,030,949)	353,183	(332,660; 373,706)
Female – intervention C	2,151,978,098	(2,151,766,864; 2,151,189,332)	511,441	(491,568; 531,315)
Male & Female – intervention A	4,960,982,813	(4,960,498,588; 4,961,467,038)	Comparator	
Male & Female – intervention B	4,961,548,806	(4,961,063,443; 4,962,034,170)	565,994	(543,181; 588,806)
Male & Female – intervention C	4,961,736,691	(4,961,251,067; 4,962,222,315)	753,878	(732,153; 775,602)

** As the decision analytic model was developed within the Bayesian framework, "credible intervals" were reported instead of "confidence intervals"*

7.2.5. Probabilistic sensitivity analysis for intervention C compared to B - Using the Vietnam Government cost-norm

Figures 24 - 26 show the results of probabilistic analysis for intervention for male group, female group and for both male and female group, respectively, level C compared to B.

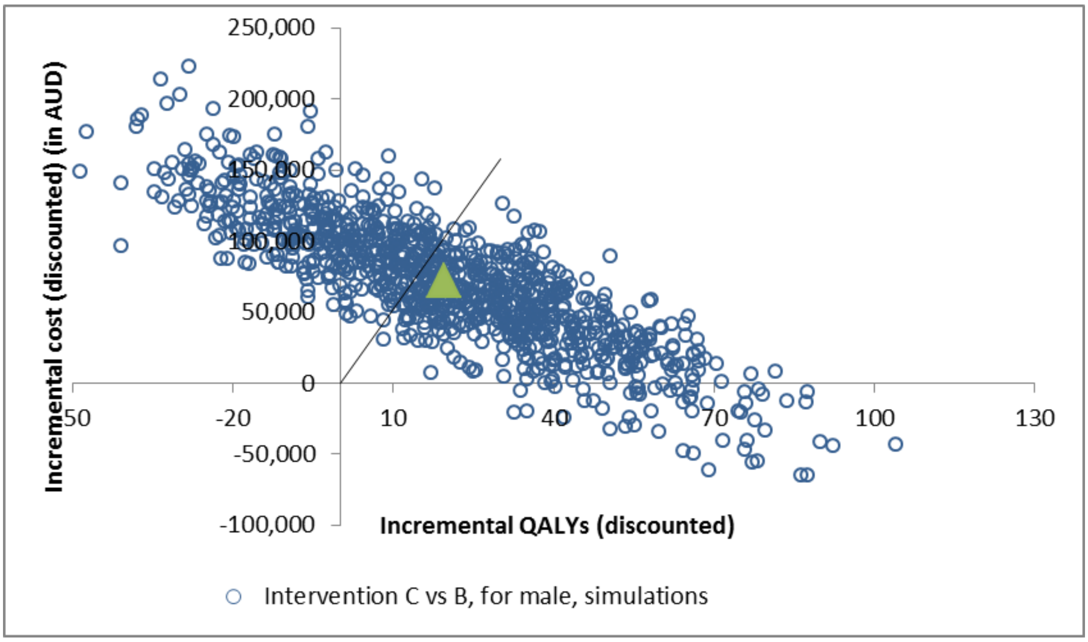


Figure 24: Probabilistic results for intervention C vs. B for males on Incremental CE plane – the Vietnam Government cost norm

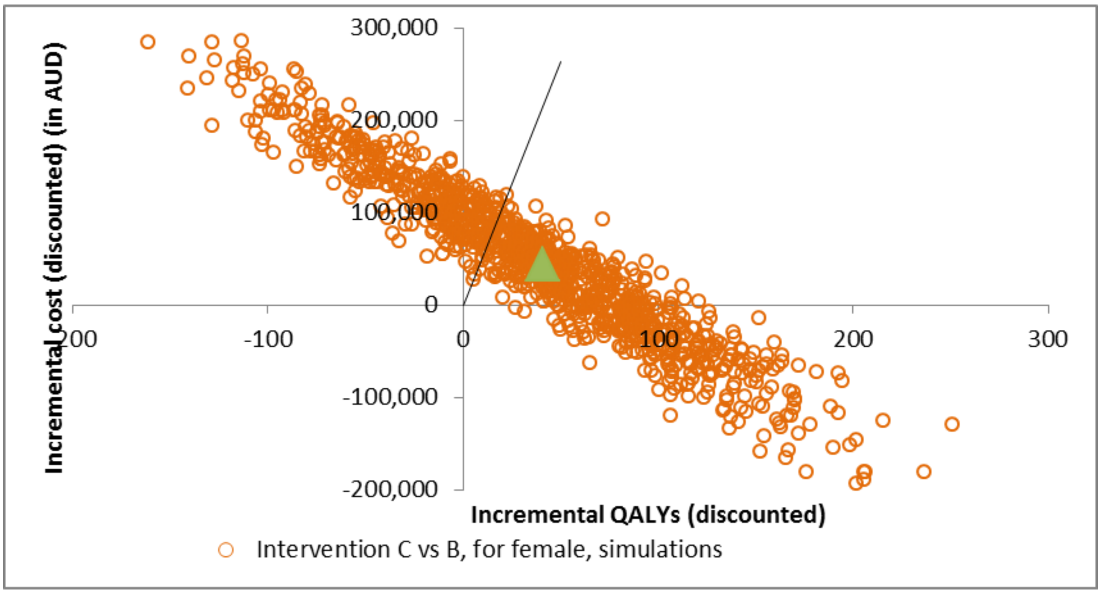


Figure 25: Probabilistic results for intervention C vs. B for females on Incremental CE plane – the Vietnam Government cost norm

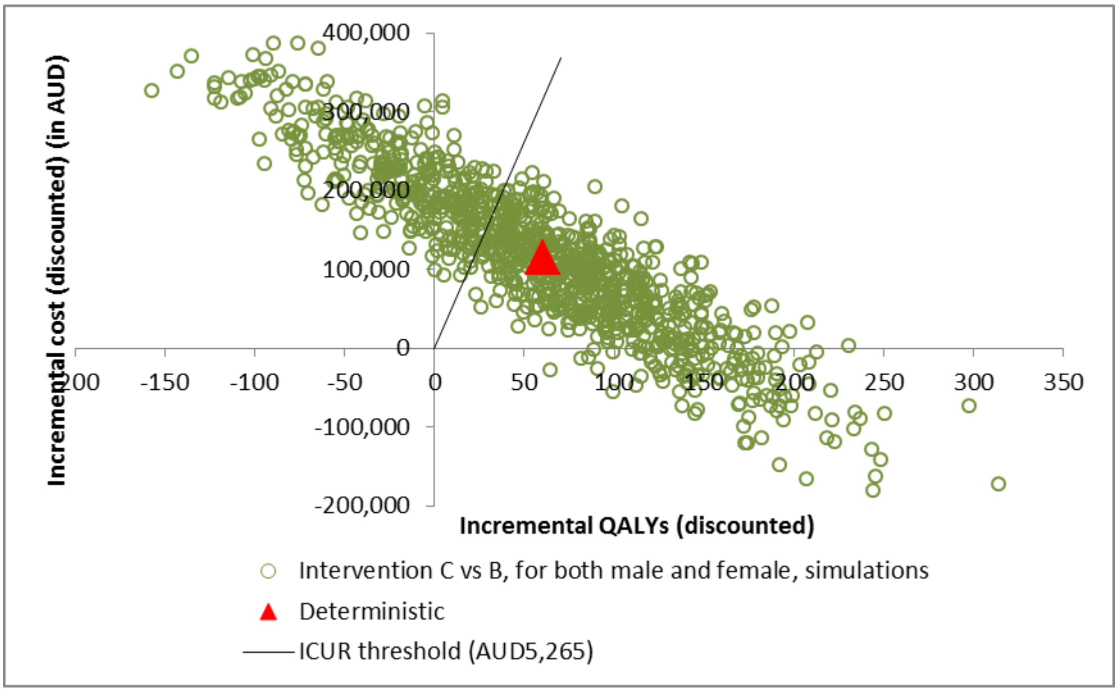


Figure 26: Probabilistic results for intervention C vs. B for both males and females on Incremental CE plane – the Vietnam Government cost norm

These above figures show that at the ceiling ratio of λ = AUD5,265, there was a chance of 57.8%, 64.9% and 66.8% that intervention C for males, females and a group of both males and females, respectively, was cost-effective compared with intervention B.

The net monetary benefit (NMB) for the different interventions was calculated using the willingness-to-pay ratio of AUD 5,265. The NMB and the incremental NMB are reported along with their 95% credible intervals in Table 23 for a cohort of 50,000 males and 50,000 females.

Compared to intervention level B, implementation of intervention level C for female participants was a beneficial option with the value of overall expected incremental NMB higher than zero (AUD158,258). For male participants, implementation of intervention level C was also a beneficial option as the overall expected incremental NMB higher than zero (AUD29,626). For both male and female participants, implementation of intervention level C over level B was a beneficial option with the value of overall expected incremental NMB higher than zero (AUD187,844). The 95% credible intervals of the NMB for males or females or both males and females did not span zero value, indicating the certainty surrounding the decision.

Table 23: NMB of different levels of education interventions at a ICER threshold of AUD5,265/QALYs (the Vietnam Government cost norm)

Cost norm from Ford Foundation	Total NMB (in AUD)		Incremental NMB (in AUD)	
	Mean	95% credible interval*	Mean	95% credible interval
Male – intervention B	2,809,728,967	(2,809,454,105; 2,810,003,828)	Comparator	
Male – intervention C	2,809,758,593	(2,809,483,655; 2,810,033,531)	29,626	(18,413; 40,840)
Female – intervention B	2,151,819,840	(2,151,608,731; 2,152,030,949)	Comparator	
Female – intervention C	2,151,978,098	(2,151,766,864; 2,151,189,332)	158,258	(130,263; 186,254)
Male & Female – intervention B	4,961,548,806	(4,961,063,443; 4,962,034,170)	Comparator	
Male & Female – intervention C	4,961,736,691	(4,961,251,067; 4,962,222,315)	187,844	(158,111; 217,658)

** As the decision analytic model was developed within the Bayesian framework, "credible intervals" were reported instead of "confidence intervals"*

7.2.6. Optimal cost-effectiveness decision – Using the Vietnam Government cost-norm

Figures 27 - 29 show the Cost-Effectiveness Acceptability Frontiers (CEAFs) for different education intervention levels for males only, females only, and for both male and female participants, respectively. The CEAF plots only the interventions with the highest probability of being cost-effective at different values of ceiling ratio, λ.

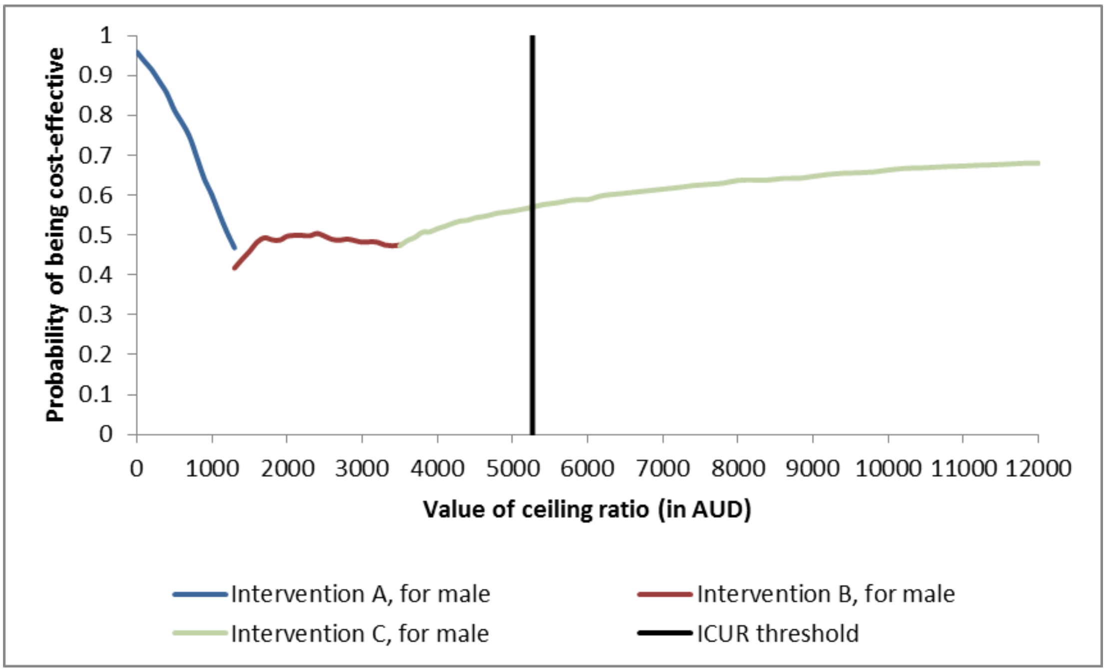


Figure 27: CEAF of different education intervention levels for males at different values of ICER threshold – the Vietnam Government cost norm

For male, up to a ceiling ratio of λ = AUD1,300 the optimal choice would be intervention level A. For values in the range between AUD1,300 and AUD3,500, the optimal choice would be intervention level B. For values over AUD3,500, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level C had the highest probability of being cost-effective.

For female, up to a ceiling ratio of λ = AUD400 the optimal choice would be intervention level A. For values in the range between AUD400 and AUD1,200, the optimal choice would be intervention level B. For values over AUD1,200, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level C had the highest probability of being cost-effective.

For a group of both male and female, up to a ceiling ratio of λ = AUD800 the optimal choice would be intervention level A. For values in the range between AUD800 and AUD1,900, the optimal choice would be intervention level B. For values over AUD1,900, the optimal choice would be intervention level C. At the ICER threshold of AUD5,265, intervention level C had the highest probability of being cost-effective.

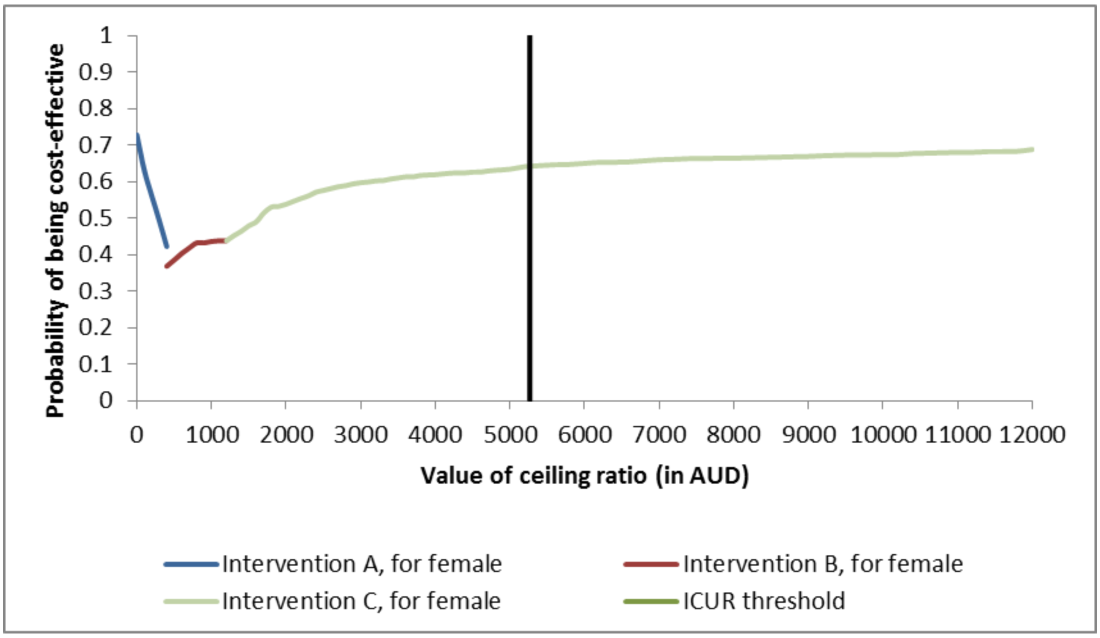


Figure 28: CEAF of different education intervention levels for females at different values of ICER threshold – the Vietnam Government cost norm

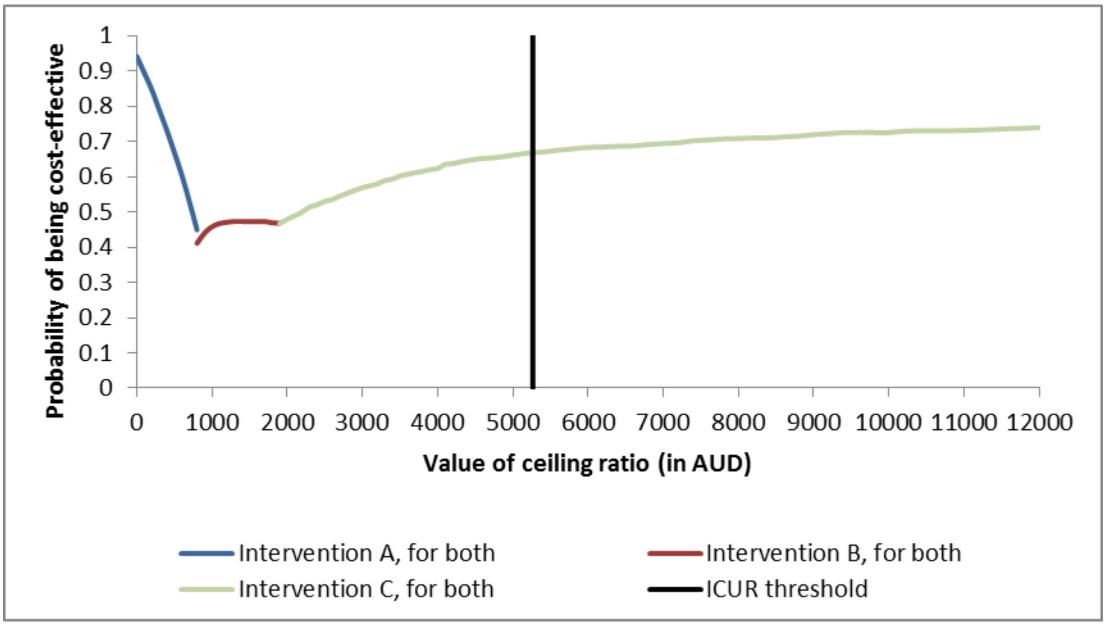


Figure 29: CEAF of different education intervention levels for males and females at different values of ICER threshold – the Vietnam Government cost norm

7.3. Scenario analysis

In order to address the uncertainty relating to the input parameters on effectiveness of the reproductive health education intervention, a total of six parameters are varied simultaneously within their pre-specified ranges and the impact on the overall results are examined. The range for the effectiveness parameters is varied incrementally between worse by 75% and better by 40%.

Those parameters are:

1. Risk of becoming sexually active within any 3 month period
2. Change in the proportion of having premarital sexual intercourses in site B vs. site A, and site C vs. site A, for male and female groups, separately.
3. Change in the proportion of using condoms among sexually active adolescents in their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
4. Change in the proportion of using condom properly/correctly among sexually active adolescents at their previous sexual intercourse in site B vs. site A, and site C vs. site A, for male and female groups, separately.
5. Change in the average number of sexual intercourse events within 3 months among sexually active adolescents in site B vs. site A, and site C vs. site A, for male and female groups, separately.
6. Change in the average number of partners per sexually active adolescent within the last 3 months in site B vs. site A, and site C vs. site A, for male and female groups, separately.

7.3.1. Sensitivity analysis of intervention for males – the Ford Foundation cost norm

As expected, intervention level B compared to A for male participants remained cost-effective as the effectiveness of the education intervention improved. The interpretation changed as the effectiveness worsened with the adoption decision switching when the effectiveness was “worse by 5%”. Here the ICER was AUD5,283.

Compared to intervention level B, intervention level C for males would be only cost-effective if the effectiveness of the education intervention was better by 40% (ICER was AUD4,742) or higher, even if the effectiveness was better by 30%, the intervention would not be cost-effective (ICER was AUD5,395).

Table 24: Results of the sensitivity analysis for intervention effectiveness parameters for males using the Ford Foundation cost-norm

Scenarios	**Intervention B vs. Intervention A**				**Intervention C vs. Intervention B**			
	Incremental Cost *(discounted-in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**	**Incremental Cost** *(discounted–in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**
Better by 40%	218,674	94.45	2,315	**Yes**	150,578	31.75	4,742	**Yes**
Better by 30%	231,008	84.14	2,745	**Yes**	154,308	28.60	5,395	**No**
Better by 20%	242,861	74.19	3,273	**Yes**	157,998	25.47	6,202	**No**
Better by 10%	254,190	64.63	3,933	**Yes**	161,620	22.39	7,217	**No**
Baseline	264,949	55.51	4,773	**Yes**	165,145	19.38	8,521	**No**
Worse by 3%	268,058	52.87	5,070	**Yes**	166,179	18.49	8,985	**No**
Worse by 5%	270,099	51.13	5,283	**No**	166,862	17.91	9,317	**No**
Worse by 10%	275,089	46.87	5,869	**No**	168,543	16.47	10,236	**No**

Figures 30 and 31 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

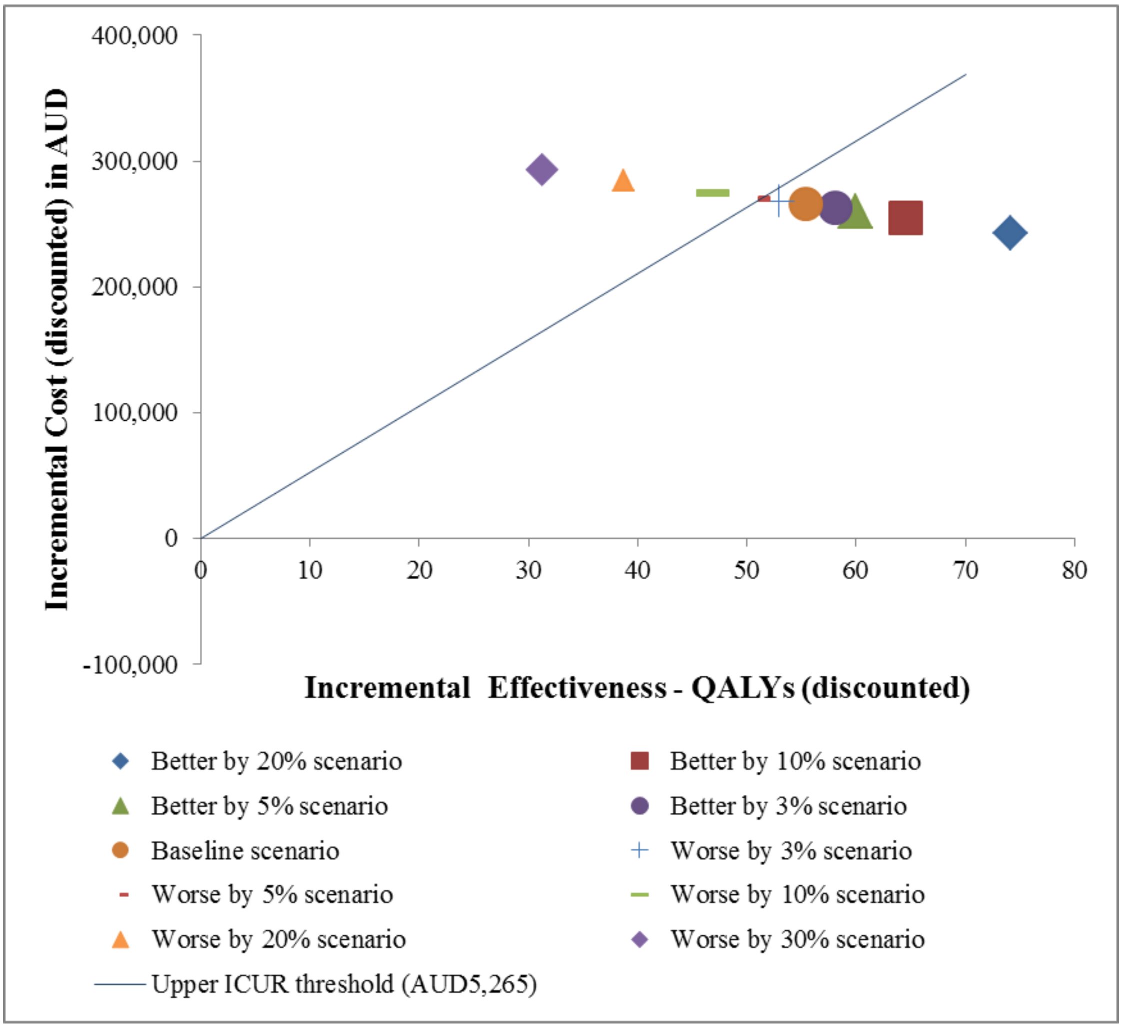


Figure 30: Sensitivity analysis of the ICER of intervention B compared to A for Males when the intervention effectiveness is changed – the Ford Foundation cost norm

The ICER of intervention level B compared to intervention level A for male participants calculating for "worse by 5%" of effectiveness of the intervention lies above the ICER threshold line indicating at that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

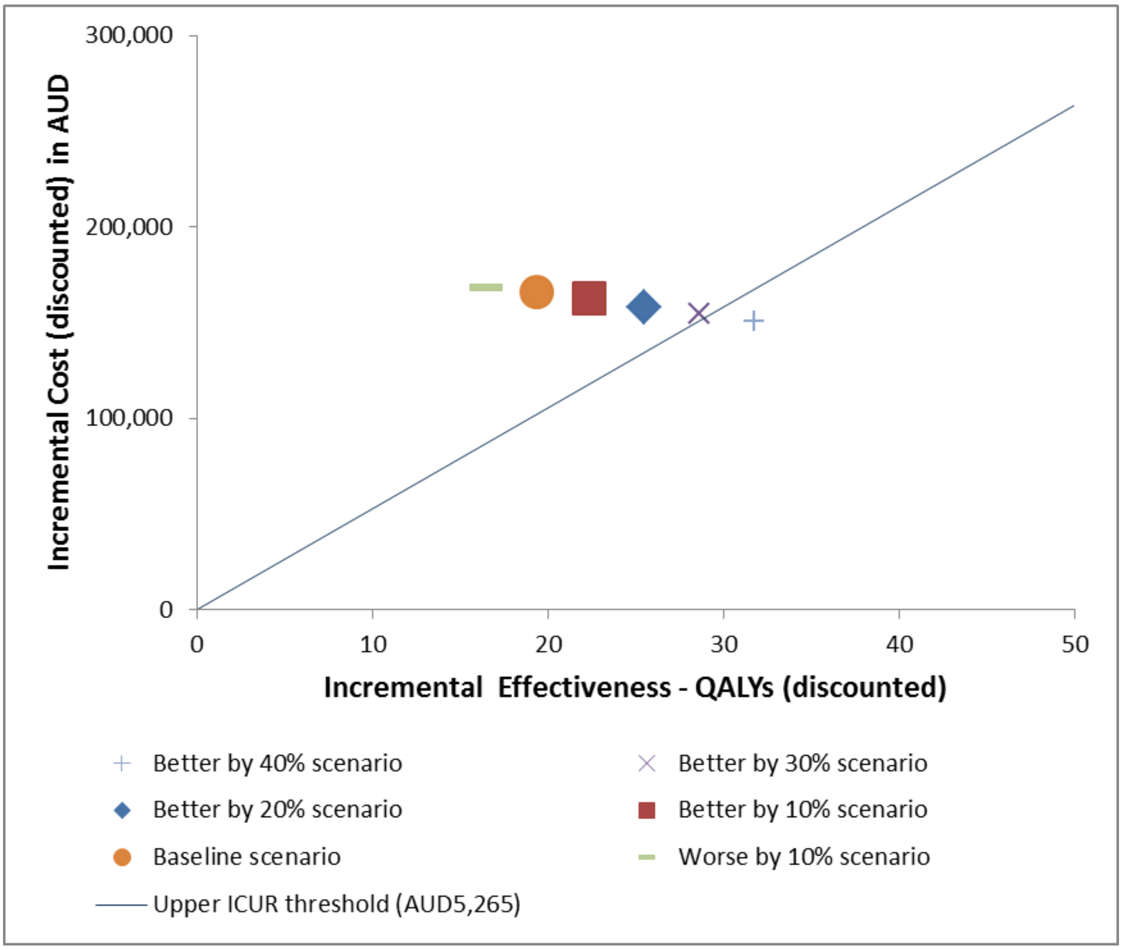


Figure 31: Sensitivity analysis of the ICER of intervention C compared to B for Males when the intervention effectiveness is changed – the Ford Foundation cost norm

Only the ICER calculating for "better by 40%" scenario lies under the ICER threshold line indicating at that level of effectiveness, intervention level C would be cost-effective compared to intervention B. However, the ICERs of intervention level C compared to intervention level B for male participants calculating for "better by 30%, 20%, 10%", "baseline" and all the "worse scenarios at all levels" of effectiveness of the intervention lie above the ICER threshold line indicating at that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 25 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 25: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for males using the Ford Foundation cost-norm

Scenarios	Intervention B vs. Intervention A			Intervention C vs. Intervention B		
	Probability of B being cost-effective compared to A	Incremental NMB *(in AUD)*		Probability of C being cost-effective compared to B	Incremental NMB *(in AUD)*	
		Mean	95% Credible Interval		Mean	95% Credible Interval
Better by 40%	92.4%	275,590	(263,641; 287,538)	51.7%	12,914	(-682; 26,509)
Better by 30%	85.8%	208,329	(195,712; 220,945)	46.8%	-10,860	(-24,273; 2,554)
Better by 20%	80.2%	145,100	(134,156; 156,043)	46.1%	-21,041	(-33,673; -8,410)
Better by 10%	68.5%	79,249	(67,926; 90,572)	40.9%	-45,522	(-58,333; -32,711)
Baseline	59.4%	34,422	(23,545; 45,300)	36.5%	-73,962	(-86,070; -61,856)
Worse by 3%	50.8%	3,692	(-6,827; 14,211)	35.6%	-68,941	(-80,928; -56,954)
Worse by 5%	49.6%	-6,267	(-17,008; 4,473)	34.8%	-71,716	(-83,860; -59,573)
Worse by 10%	41.5%	-41,235	(-51,497; -30,973)	34.0%	-75,625	(-88,163; -63,087)

Results from the probabilistic analysis for different levels of effectiveness parameters showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of “better at all levels” and “baseline” scenarios when comparing B to A, and the 95% incredible intervals of all examined scenarios except for “better by 30%, 40%” scenarios when comparing C to B, did not span zero, indicating the certainty surrounding the decision.

7.3.2. Sensitivity analysis of intervention for females – the Ford Foundation cost norm

Compared to intervention level A, implementation of education intervention level B for female participants remained cost-effective when the intervention effectiveness improved or worsened. The final decision changed as the effectiveness worsened “by 35%”. Here the ICER was AUD5,483.

Compared to intervention level B, implementation of intervention level C for females remained cost-effective as the effectiveness of the education intervention changed to “worse by different levels no higher than 30%”. The intervention turned into not cost-effective only when the effectiveness of the intervention was “worse by 35%”.

Table 26: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for females using the Ford Foundation cost-norm

Scenarios	Intervention B vs. Intervention A				Intervention C vs. Intervention B			
	Incremental Cost *(discounted-in AUD)*	Incremental QALYs *(discounted)*	ICER	Cost – effective?	Incremental Cost *(discounted–in AUD)*	Incremental QALYs *(discounted)*	ICER	Cost – effective?
Better by 40%	189,916	113.10	1,679	**Highly**	116,692	56.50	2,065	**Yes**
Better by 30%	201,478	104.39	1,930	**Yes**	121,715	52.74	2,308	**Yes**
Better by 20%	212,859	95.74	2,223	**Yes**	126,786	48.92	2,592	**Yes**
Better by 10%	224,045	87.16	2,571	**Yes**	131,892	45.04	2,928	**Yes**
Baseline	235,020	78.65	2,988	**Yes**	137,016	41.12	3,332	**Yes**
Worse by 10%	245,769	70.22	3,500	**Yes**	142,135	37.17	3,824	**Yes**
Worse by 20%	256,281	61.88	4,141	**Yes**	147,220	33.22	4,431	**Yes**
Worse by 30%	266,547	53.63	4,970	**Yes**	152,225	29.31	5,194	**Yes**
Worse by 35%	271,588	49.53	5,483	**No**	154,678	27.38	5,649	**No**

Figures 32 and 33 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

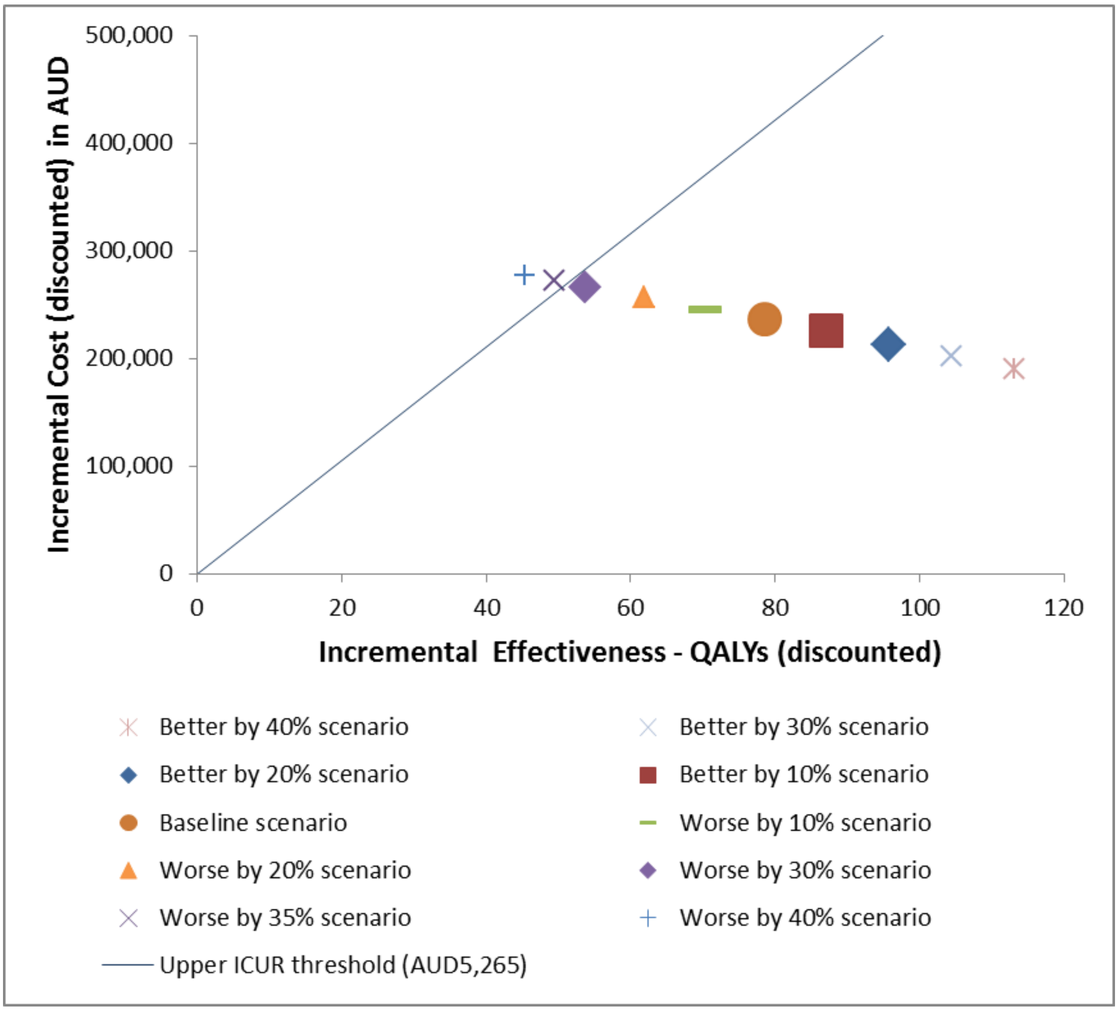


Figure 32: Sensitivity analysis of the ICER of intervention B compared to A for females when the intervention effectiveness is changed – the Ford Foundation cost norm

The ICERs of intervention level B compared to intervention level A for female participants calculating for "worse by 35%" and "worse by 40%" of effectiveness of the intervention lie above the ICER threshold line indicating at that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

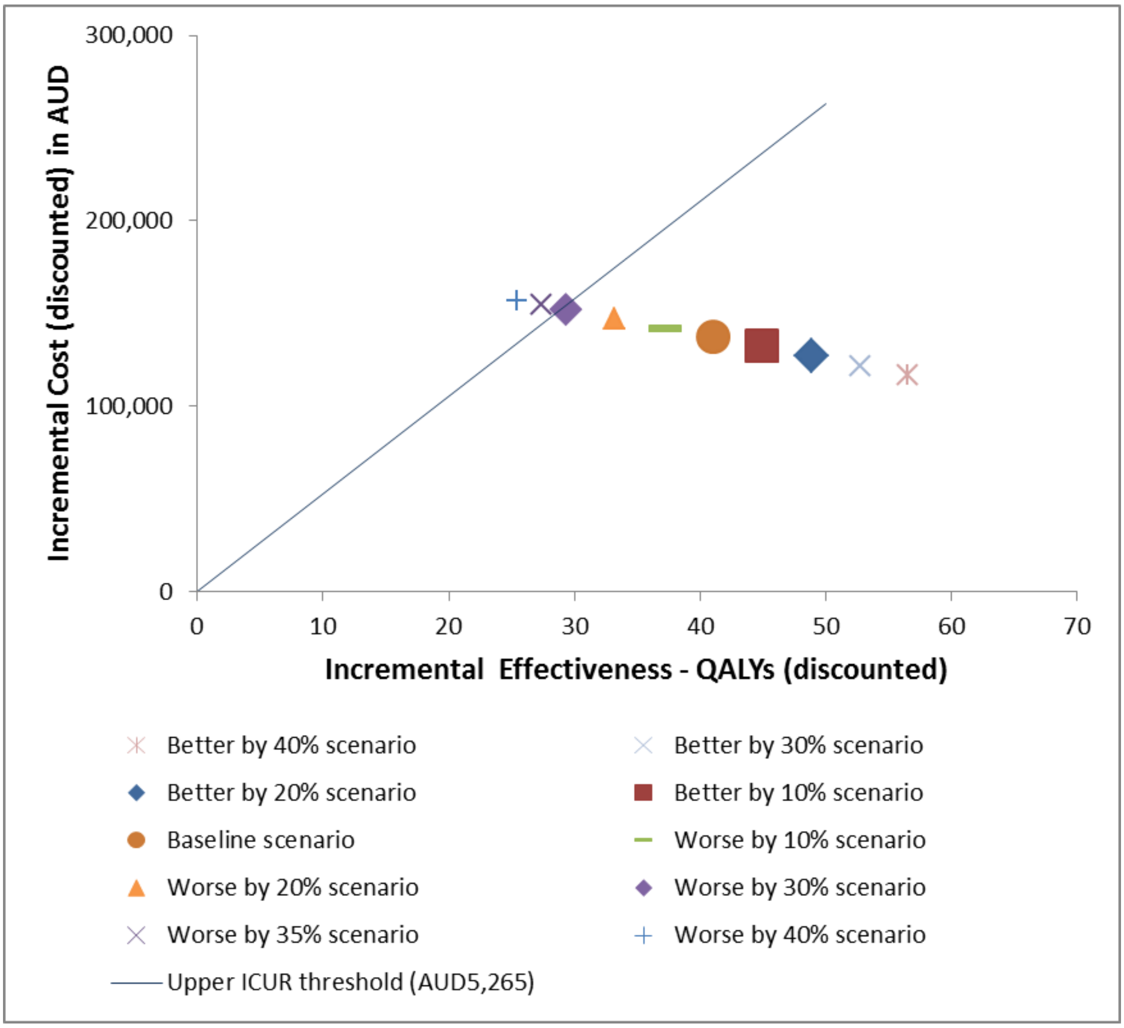


Figure 33: Sensitivity analysis of the ICER of intervention C compared to B for Females when the intervention effectiveness is changed – the Ford Foundation cost norm

The ICER of intervention level C compared to intervention level B for female participants calculating for the “worse by 35%” of effectiveness of the intervention lies above the ICER threshold line indicating from that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 27 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 27: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for females using the Ford Foundation cost-norm

Scenarios	Intervention B vs. Intervention A			Intervention C vs. Intervention B		
	Probability of B being cost-effective compared to A	Incremental NMB *(in AUD)*		Probability of C being cost-effective compared to B	Incremental NMB *(in AUD)*	
		Mean	95% Credible Interval		Mean	95% Credible Interval
Better by 40%	86.2%	386,595	(364,952; 408,238)	65.4%	185,183	(158,184; 212,182)
Better by 30%	83.3%	320,723	(299,432; 342,013)	65.1%	169,306	(142,038, 196,574)
Better by 20%	81.1%	272,378	(251,473; 293,283)	62.6%	131,312	(104,755; 157,869)
Better by 10%	74.6%	216,078	(194,563; 237,592)	57.4%	92,421	(64,712; 120,130)
Baseline	69.2%	161,533	(139,052; 184,014)	55.0%	79,436	(50,576; 108,297)
Worse by 10%	63.2%	98,085	(76,981; 119,190)	54.6%	41,214	(13,360, 69,069)
Worse by 20%	58.3%	38,905	(16,190; 61,619)	51.2%	27,789	(-1,100; 56,678)
Worse by 30%	52.8%	-6,414	(-27,252; 14,423)	50.0%	-1,762	(-29,943; 26,419)
Worse by 35%	48.1%	-34,433	(-55,944; -12,923)	49.6%	-21,721	(-50,849; 7,406)

Results from the probabilistic analysis for different levels of effectiveness parameters also showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of “better at all levels”, “worse by 10%, 20%” scenarios when comparing B to A, the 95% incredible intervals of “better at all levels”, “worse by 10%” scenarios when comparing C to B did not span zero, indicating the certainty surrounding the decision.

7.3.3. Sensitivity analysis of intervention for both males and females – the Ford Foundation cost norm

Compared to intervention level A, implementation of education intervention level B for both male and female participants remained cost-effective when the education intervention effectiveness improved or worsened by 5%, 10%, 15%. Intervention level B would no longer be cost-effective if the effectiveness of the intervention was “worse by 20% and higher”.

Compared to intervention level B, implementation of education intervention level C for both males and females remained cost-effective as the effectiveness of the education intervention improved. The interpretation changed as the effectiveness changed to “worse by 5%”. Here the ICER was AUD5,371.

Table 28: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for both males and females using the Ford Foundation cost-norm

Scenarios	**Intervention B vs. Intervention A**				**Intervention C vs. Intervention B**			
	Incremental Cost *(discounted-in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**	**Incremental Cost** *(discounted–in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**
Better by 30%	432,486	188.53	2,294	**Yes**	276,023	81.34	3,393	**Yes**
Better by 20%	455,721	169.93	2,682	**Yes**	284,784	74.39	3,828	**Yes**
Better by 10%	478,235	151.79	3,150	**Yes**	293,512	67.43	4,353	**Yes**
Baseline	499,969	134.16	3,726	**Yes**	302,161	60.50	4,994	**Yes**
Worse by 5%	510,523	125.56	4,066	**Yes**	306,440	57.05	5,371	**No**
Worse by 10%	520,859	117.10	4,448	**Yes**	310,678	53.64	5,792	**No**
Worse by 15%	530,967	108.79	4,880	**Yes**	314,868	50.25	6,266	**No**
Worse by 20%	540,841	100.65	5,374	**No**	319,000	46.90	6,802	**No**

Figures 34 and 35 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

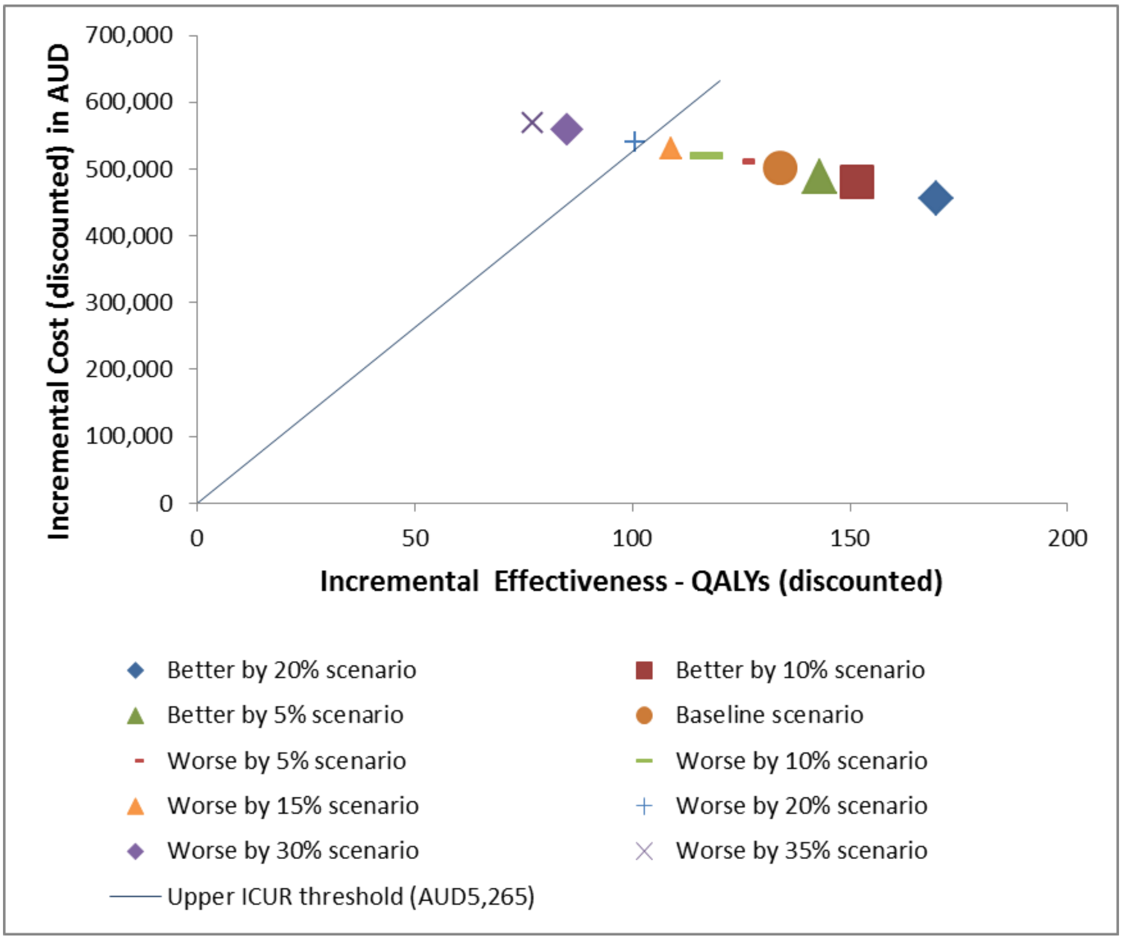


Figure 34: Sensitivity analysis of the ICER of intervention B compared to A for both males and females when the intervention effectiveness is changed – the Ford Foundation cost norm

The ICERs of intervention level B compared to intervention level A for both male and female participants calculating for “worse by 20%” and “worse by 30%” of effectiveness of the intervention lie above the ICER threshold line, indicating at that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

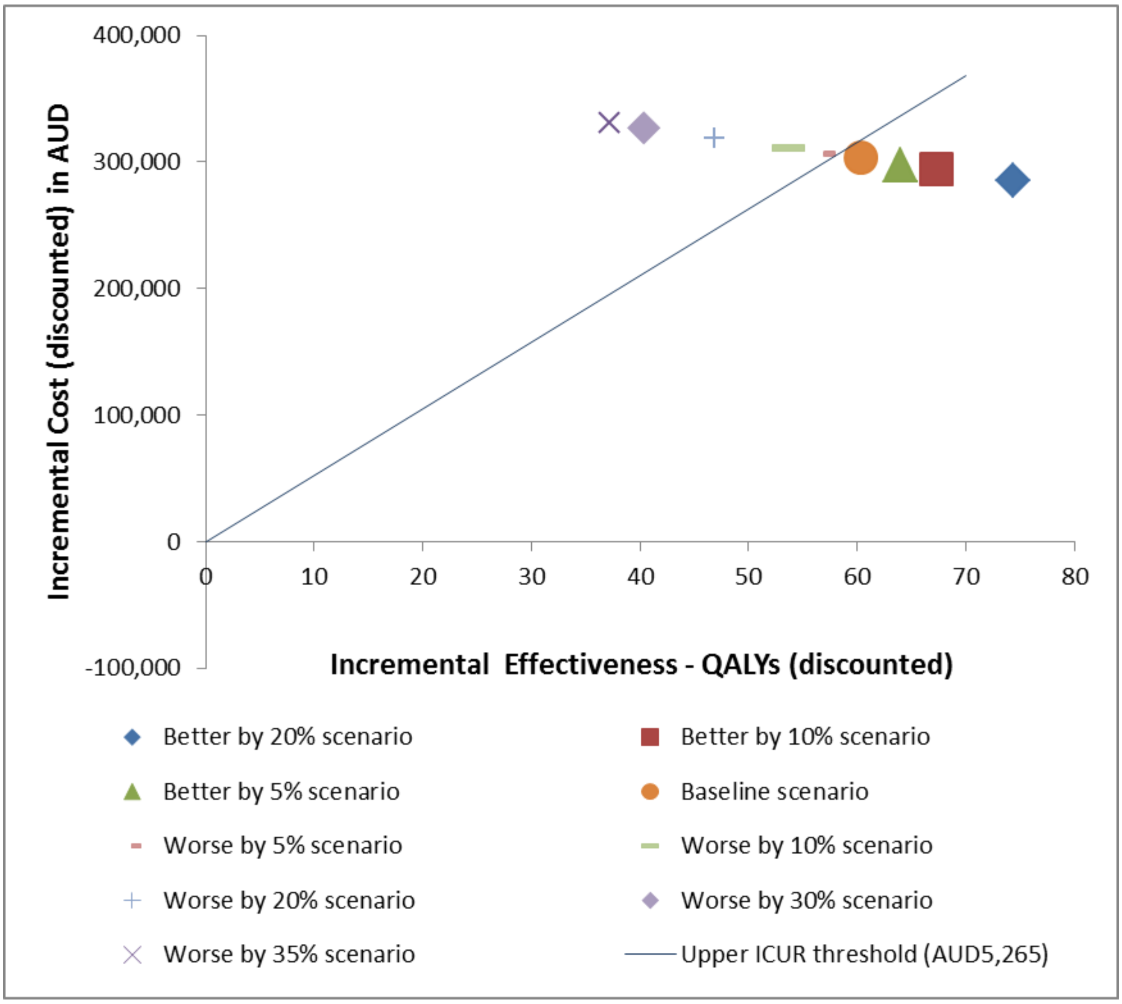


Figure 35: Sensitivity analysis of the ICER of intervention C compared to B for both males and females when the intervention effectiveness is changed – the Ford Foundation cost norm

The ICER of intervention level C compared to intervention level B calculating for the "worse by 5%" of effectiveness of the intervention lies above the ICER threshold line indicating from that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 29 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 29: Results of the sensitivity analysis considering uncertainty for intervention effectiveness parameters for both males and females using the Ford Foundation cost-norm

Scenarios	Intervention B vs. Intervention A			Intervention C vs. Intervention B		
	Probability of B being cost-effective compared to A	Incremental NMB *(in AUD)*		Probability of C being cost-effective compared to B	Incremental NMB *(in AUD)*	
		Mean	95% Credible Interval		Mean	95% Credible Interval
Better by 40%	95.0%	662,184	(637,134; 687,235)	65.5%	198,097	(166,504; 229,690)
Better by 30%	90.6%	529,052	(504,593; 553,510)	63.6%	158,446	(127,745; 189,148)
Better by 20%	85.9%	417,478	(393,120; 441,836)	58.1%	110,271	(79,862; 140,679)
Better by 10%	77.4%	295,327	(270,361; 320,293)	53.9%	46,899	(15,685; 78,112)
Baseline	70.5%	195,955	(170,974; 220,937)	50.7%	5,473	(-26,659; 37,605)
Worse by 5%	63.4%	119,198	(94,901; 143,494)	48.3%	-2,444	(-34,153; 29,264)
Worse by 10%	56.7%	56,851	(32,735; 80,967)	48.0%	-34,411	(-66,021; -2,801)
Worse by 15%	52.2%	11,426	(-12,878; 35,731)	46.0%	-46,935	(-78,372; -15,498)
Worse by 20%	47.1%	-50,105	(-74,923; -25,286)	44.9%	-59,023	(-90,661; -27,385)

Results from the probabilistic analysis for different levels of effectiveness parameters also showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of “better at all levels”, “worse by 5%, 10%” scenarios when comparing B to A, the 95% incredible intervals of “better at all levels”, “worse by 10%, 15%, 20%” scenarios when comparing C to B did not span zero, indicating the certainty surrounding the decision.

7.3.4. Sensitivity analysis of intervention for males – the Vietnam Government cost norm

Compared to intervention level A, implementation of education intervention level B for male participants remained cost-effective when the education intervention effectiveness improved and worsened. The ICER was higher than three times GDP per capita only when the effectiveness of the intervention changed to “worse by 45%” scenario.

Compared to intervention level B, implementation of education intervention level C for male remained cost-effective as the effectiveness of the education intervention improved or worsened by 5%, 10%, 15%. Intervention C turned into not cost-effective compared to B only when the effectiveness of the intervention was “worse by 20%”.

Table 30: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for males using the Vietnam Government cost-norm

Scenarios	Intervention B vs. Intervention A				Intervention C vs. Intervention B			
	Incremental Cost *(discounted-in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**	**Incremental Cost** *(discounted–in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**
Better by 20%	54,246	74.19	731	**Highly**	64,721	25.47	2,540	**Yes**
Better by 10%	65,575	64.63	1,014	**Highly**	68,343	22.39	3,052	**Yes**
Baseline	76,334	55.51	1,375	**Highly**	71,868	19.38	3,708	**Yes**
Worse by 8%	84,498	48.56	1,740	**Highly**	74,598	17.04	4,378	**Yes**
Worse by 10%	86,474	46.87	1,845	**Yes**	75,266	16.47	4,571	**Yes**
Worse by 15%	91,297	42.75	2,135	**Yes**	76,906	15.05	5,108	**Yes**
Worse by 20%	95,945	38.76	2,475	**Yes**	78,503	13.68	5,739	**No**
Worse by 40%	112,660	24.34	4,627	**Yes**	84,359	8.60	9,809	**No**
Worse by 45%	116,332	21.16	5,498	**No**	85,668	7.46	11,483	**No**

Figures 36 and 37 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

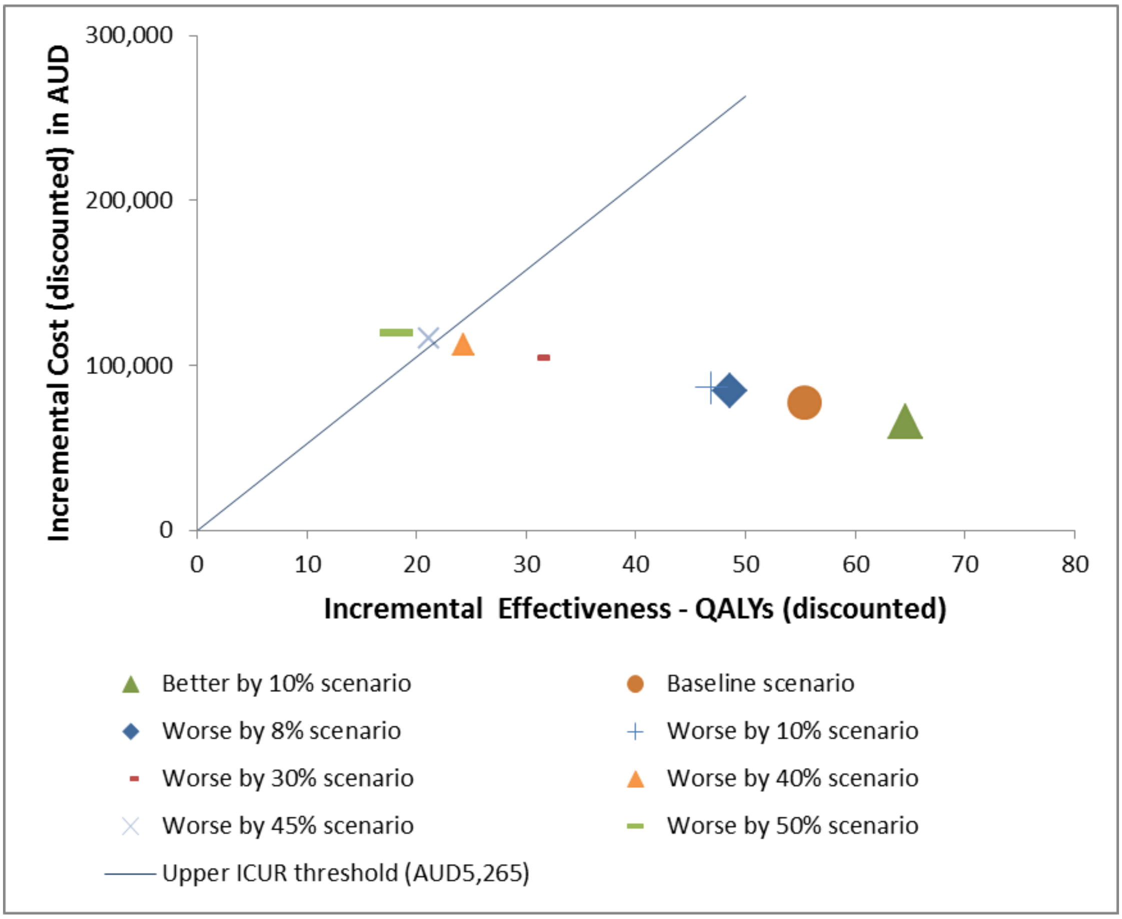


Figure 36: Sensitivity analysis of the ICER of intervention B compared to A for Males when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICER of intervention level B compared to intervention level A for male participants calculating for "worse by 45%" of effectiveness of the intervention lies above the ICER threshold line indicating from that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

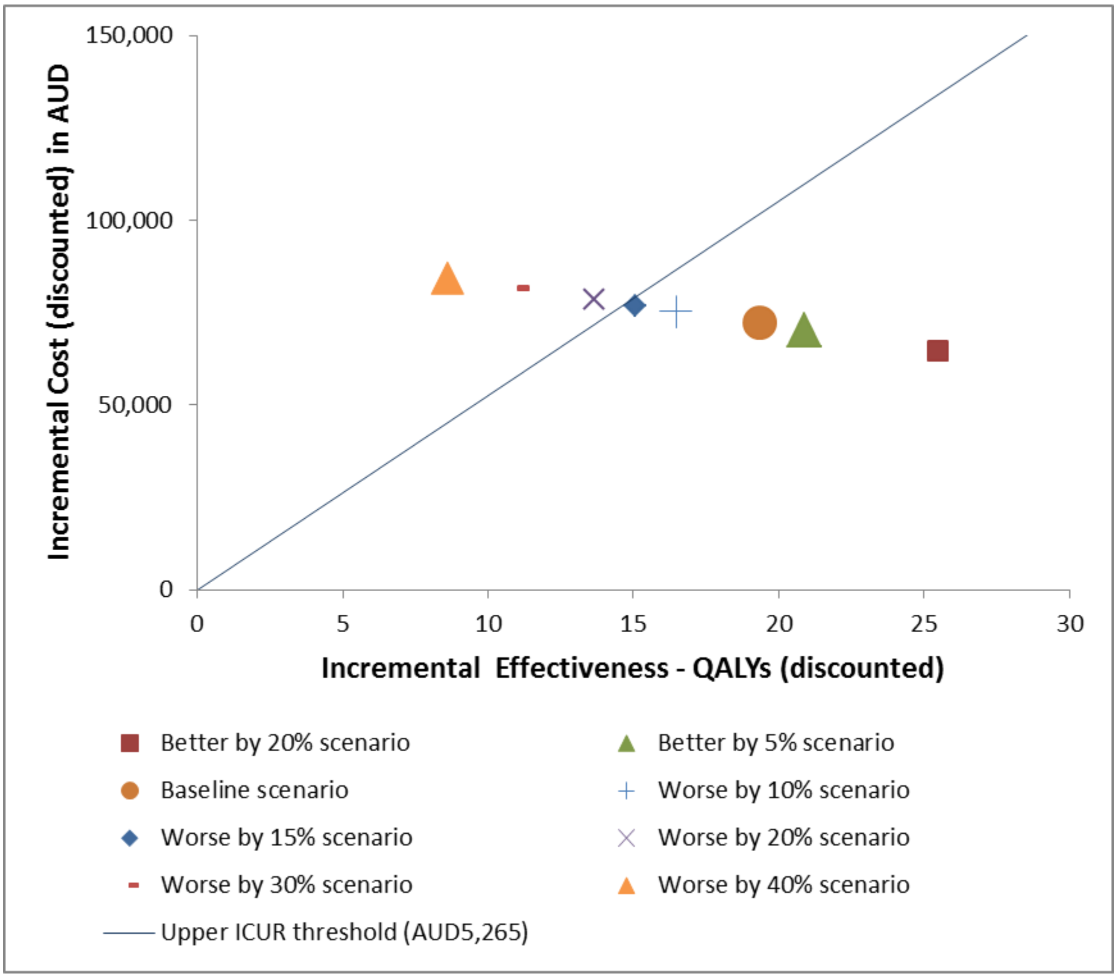


Figure 37: Sensitivity analysis of the ICER of intervention C compared to B for Males when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICER of intervention level C compared to intervention level B for male participants calculating for the "worse by 20%" of effectiveness of the intervention lies above the ICER threshold line, indicating from that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 31 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 31: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for males using the Vietnam Government cost-norm

Scenarios	**Intervention B vs. Intervention A**			**Intervention C vs. Intervention B**		
	Probability of B being cost-effective compared to A	**Incremental NMB** *(in AUD)*		**Probability of C being cost-effective compared to B**	**Incremental NMB** *(in AUD)*	
		Mean	**95% Credible Interval**		**Mean**	**95% Credible Interval**
Better by 20%	95.8%	316,479	(305,095; 327,863)	65.3%	78,583	(66,179; 90,986)
Better by 10%	93.3%	257,386	(246,729; 268,043)	63.7%	59,980	(48,413; 71,546)
Baseline	90.8%	212,810	(202,722; 222,899)	57.8%	29,626	(18,413; 40,840)
Worse by 8%	84.2%	161,381	(151,282; 171,481)	54.5%	23,475	(12,433; 34,518)
Worse by 10%	82.4%	153,993	(143,754; 164,232)	51.8%	11,441	(26; 22,855)
Worse by 15%	80.8%	128,323	(118,484; 138,161)	51.1%	5,765	(-5,033; 16,562)
Worse by 20%	76.6%	105,997	(96,513; 115,480)	48.3%	-7,183	(-17,449; 3,082)
Worse by 40%	53.0%	8,975	(990; 16,960)	37.1%	-42,771	(-51,898; -33,643)
Worse by 45%	46.4%	-8,927	(-16,769; -1,085)	36.0%	-47,623	(-56,168; -39,078)

Results from the probabilistic analysis for different levels of effectiveness parameters showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of all examined scenarios when comparing B to A, and all examined scenarios except for “worse by 15%, 20%” scenarios when comparing C to B, did not span zero, indicating the certainty surrounding the decision.

7.3.5. Sensitivity analysis of intervention for females – the Vietnam Government cost norm

Compared to intervention level A, implementation of education intervention level B for female participants remained cost-effective when the education intervention effectiveness improved and worsened. The ICER was higher than three times GDP per head only when the effectiveness of the intervention changed to “worse by 70%” scenario, here the ICER was AUD5,556.

Compared to intervention level B, implementation of education intervention level C for female participants remained cost-effective as the effectiveness of the intervention improved or worsened. The ICER was higher than three times GDP per head only when the effectiveness of the intervention changed to “worse by 75%” scenario.

Table 32: Results of the sensitivity analysis for intervention effectiveness parameters for females using the Vietnam Government cost-norm

Scenarios	**Intervention B vs. Intervention A**				**Intervention C vs. Intervention B**			
	Incremental Cost *(discounted-in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**	**Incremental Cost** *(discounted–in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**
Baseline	46,405	78.65	590	**Highly**	43,739	41.12	1,064	**Highly**
Worse by 22%	69,739	60.23	1,158	**Highly**	54,952	32.43	1,694	**Highly**
Worse by 35%	82,973	49.53	1,675	**Highly**	61,401	27.38	2,242	**Yes**
Worse by 40%	87,954	45.44	1,935	**Yes**	63,806	25.49	2,503	**Yes**
Worse by 65%	112,090	25.11	4,463	**Yes**	74,562	16.98	4,391	**Yes**
Worse by 70%	116,801	21.02	5,556	**No**	76,355	15.55	4,909	**Yes**
Worse by 75%	121,473	16.93	7,175	**No**	78,042	14.19	5,498	**No**

Figures 38 and 39 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

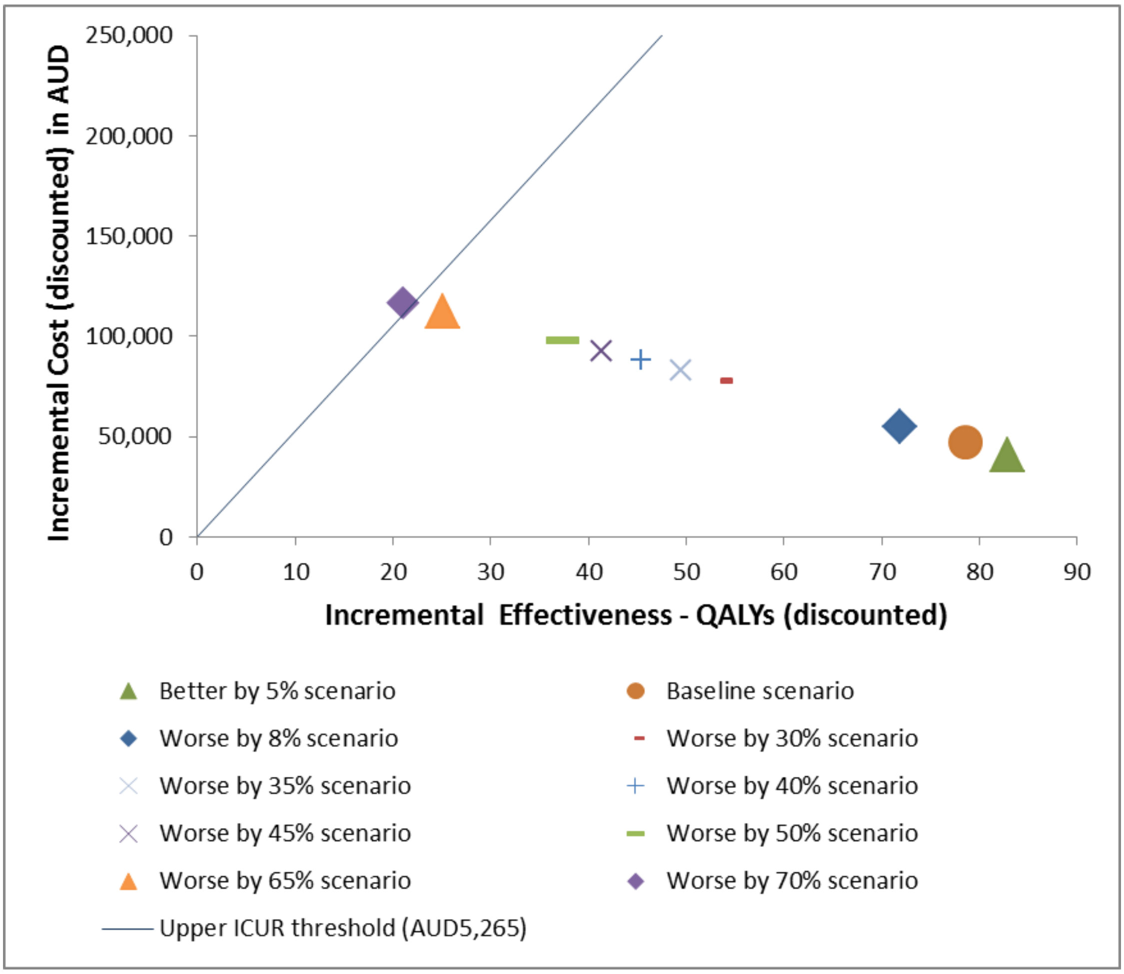


Figure 38: Sensitivity analysis of the ICER of intervention B compared to A for Females when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICER of intervention level B compared to intervention level A for female participants calculating for “worse by 70%” of effectiveness of the intervention lies above the ICER threshold line indicating from that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

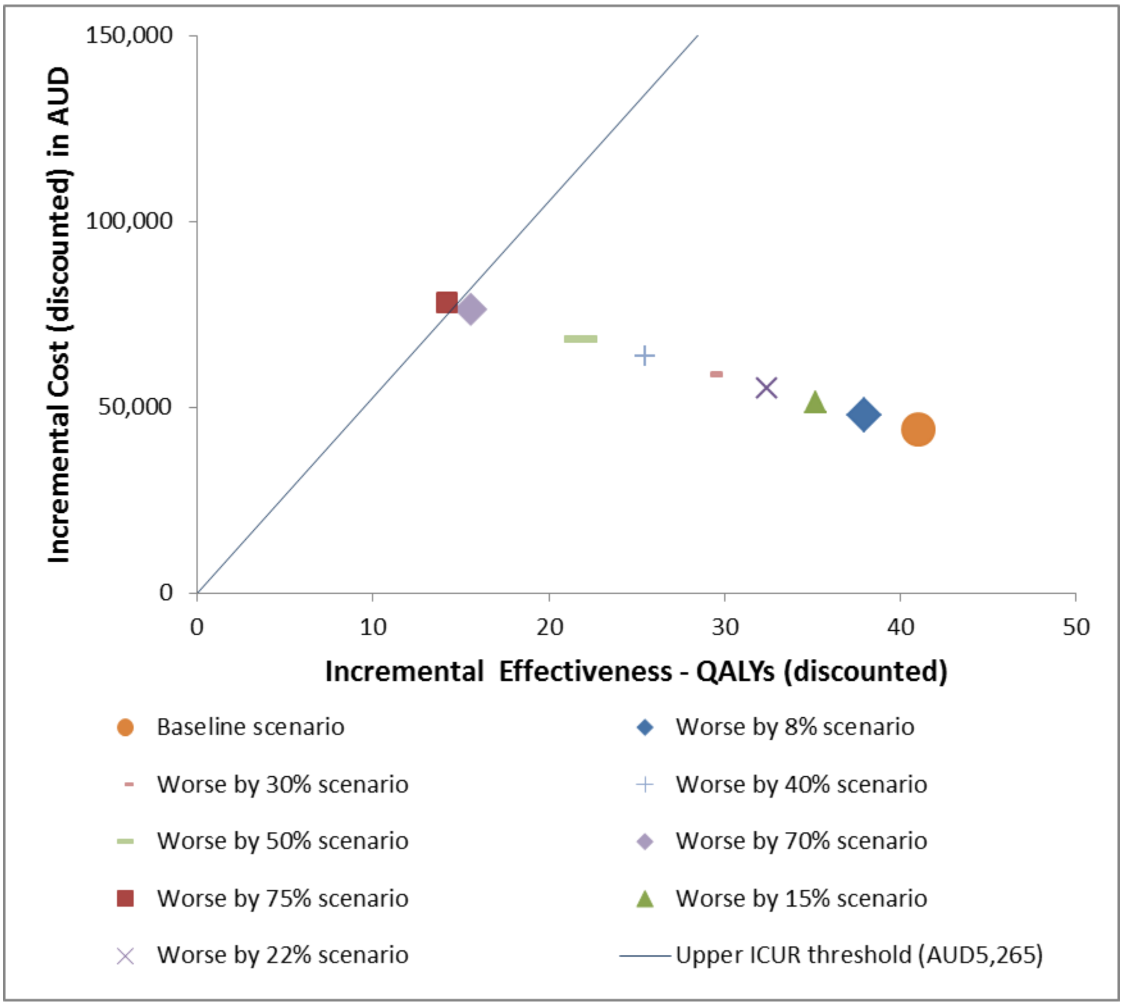


Figure 39: Sensitivity analysis of the ICER of intervention C compared to B for Females when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICER of intervention level C compared to intervention level B for male participants calculating for the “worse by 75%” of effectiveness of the intervention lies above the ICER threshold line, indicating from that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 33 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 33: Results of the sensitivity analysis considering uncertainty for intervention effectiveness parameters for females using the Vietnam Government cost-norm

Scenarios	**Intervention B vs. Intervention A**			**Intervention C vs. Intervention B**		
	Probability of B being cost-effective compared to A	**Incremental NMB** *(in AUD)*		**Probability of C being cost-effective compared to B**	**Incremental NMB** *(in AUD)*	
		Mean	**95% Credible Interval**		**Mean**	**95% Credible Interval**
Baseline	85.8%	353,183	(332,660; 373,706)	64.9%	158,258	(130,263; 186,254)
Worse by 22%	75.3%	225,398	(204,116; 246,679)	59.4%	117,477	(88,490; 146,464)
Worse by 35%	70.4%	166,033	(144,312; 187,754)	56.4%	70,494	(41,989; 98,999)
Worse by 40%	69.6%	138,530	(116,338; 160,722)	56.2%	54,415	(25,428; 83,401)
Worse by 65%	52.8%	4,943	(-14,696; 24,581)	50.5%	16,455	(-10,495; 43,406)
Worse by 70%	50.6%	-13,788	(-32,317; 4,741)	50.4%	10,613	(-15,161; 36,386)
Worse by 75%	44.1%	-57,805	(-76,342; -39,268)	49.2%	-10,819	(-37,577; 15,940)

Results from the probabilistic analysis for different levels of effectiveness parameters showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of “worse by 65%, 70%” when comparing B to A and the 95% incredible intervals of “worse by 65%, 70%, 75%” when comparing C to B did span zero, indicating the uncertainty surrounding the decision for the rest of the scenarios for effectiveness of the intervention.

7.3.6. Sensitivity analysis of intervention for both males and females – the Vietnam Government cost norm

Compared to intervention level A, implementation of education intervention level B for both male and female participants remained cost-effective when the education intervention effectiveness improved or worsened. Intervention level B would no longer be cost-effective if the effectiveness of the intervention was “worse by 60% and higher”.

Compared to intervention level B, implementation of education intervention level C for both males and females remained cost-effective when the effectiveness of the education intervention improved or worsened. The conclusion was only changed to not cost-effective from the “worse by 50%” scenario onwards.

Table 34: Results of the sensitivity analysis considering uncertainty for intervention effectiveness for both males and females using the Vietnam Government cost-norm

Scenarios	**Intervention B vs. Intervention A**				**Intervention C vs. Intervention B**			
	Incremental Cost *(discounted-in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**	**Incremental Cost** *(discounted–in AUD)*	**Incremental QALYs** *(discounted)*	**ICER**	**Cost – effective?**
Better by 5%	111,974	142.91	783	**Highly**	111,296	63.96	1,740	**Highly**
Baseline	122,739	134.16	915	**Highly**	115,607	60.50	1,911	**Yes**
Worse by 22%	167,494	97.43	1,719	**Highly**	134,081	45.57	2,942	**Yes**
Worse by 25%	173,243	92.67	1,869	**Yes**	136,511	43.60	3,131	**Yes**
Worse by 45%	209,209	62.53	3,345	**Yes**	151,817	31.10	4,882	**Yes**
Worse by 50%	217,532	55.46	3,922	**Yes**	155,318	28.23	5,502	**No**
Worse by 55%	225,581	48.59	4,642	**Yes**	158,647	25.50	6,222	**No**
Worse by 60%	233,354	41.91	5,568	**No**	161,779	22.93	7,056	**No**

Figures 40 and 41 show the results of sensitivity analysis on the incremental cost-effectiveness plane with the ICER threshold (the straight line) suggested by the WHO for Vietnam.

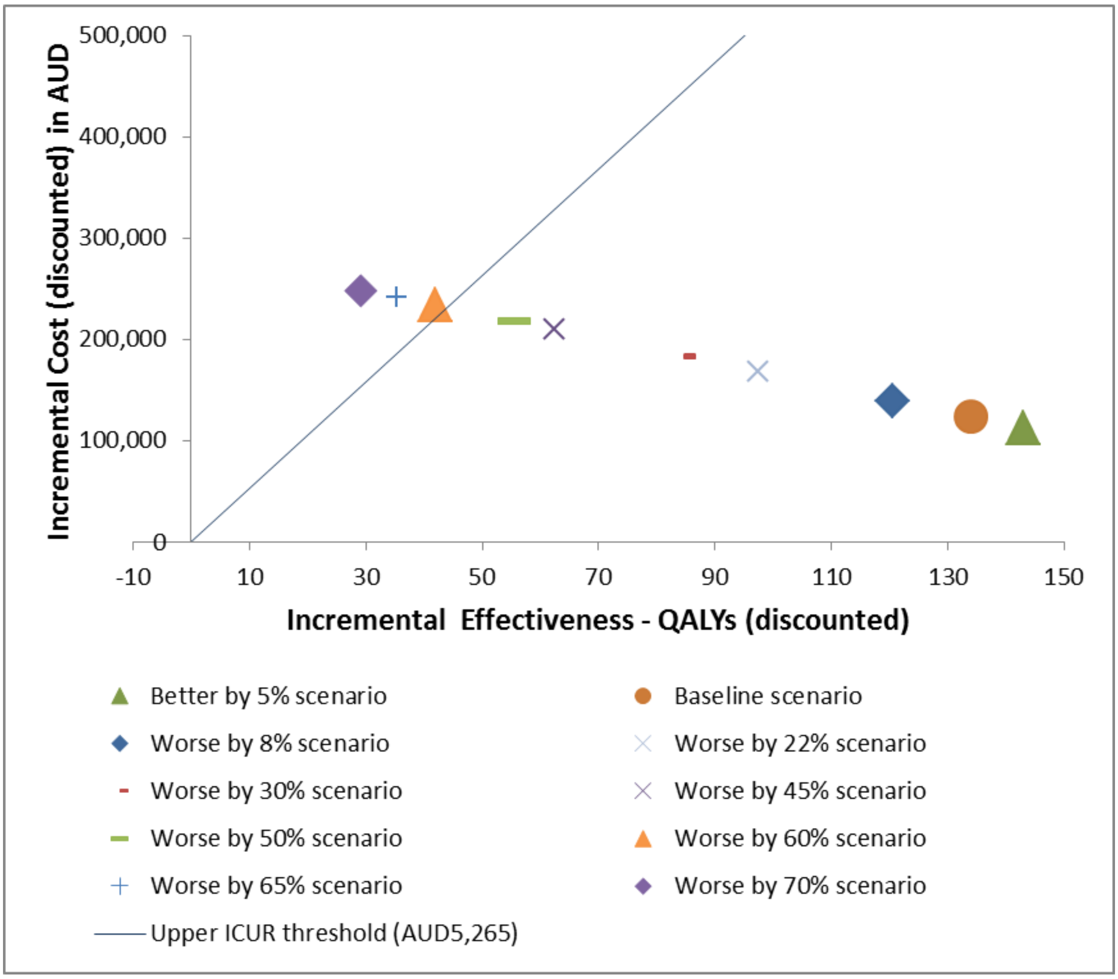


Figure 40: Sensitivity analysis of the ICER of intervention B compared to A for both males and females when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICERs of intervention level B compared to intervention level A for both male and female participants calculating for "worse by 60%" and "worse by 70%" of effectiveness of the intervention lie above the ICER threshold line indicating at that level of effectiveness, intervention level B would not be cost-effective compared to intervention A.

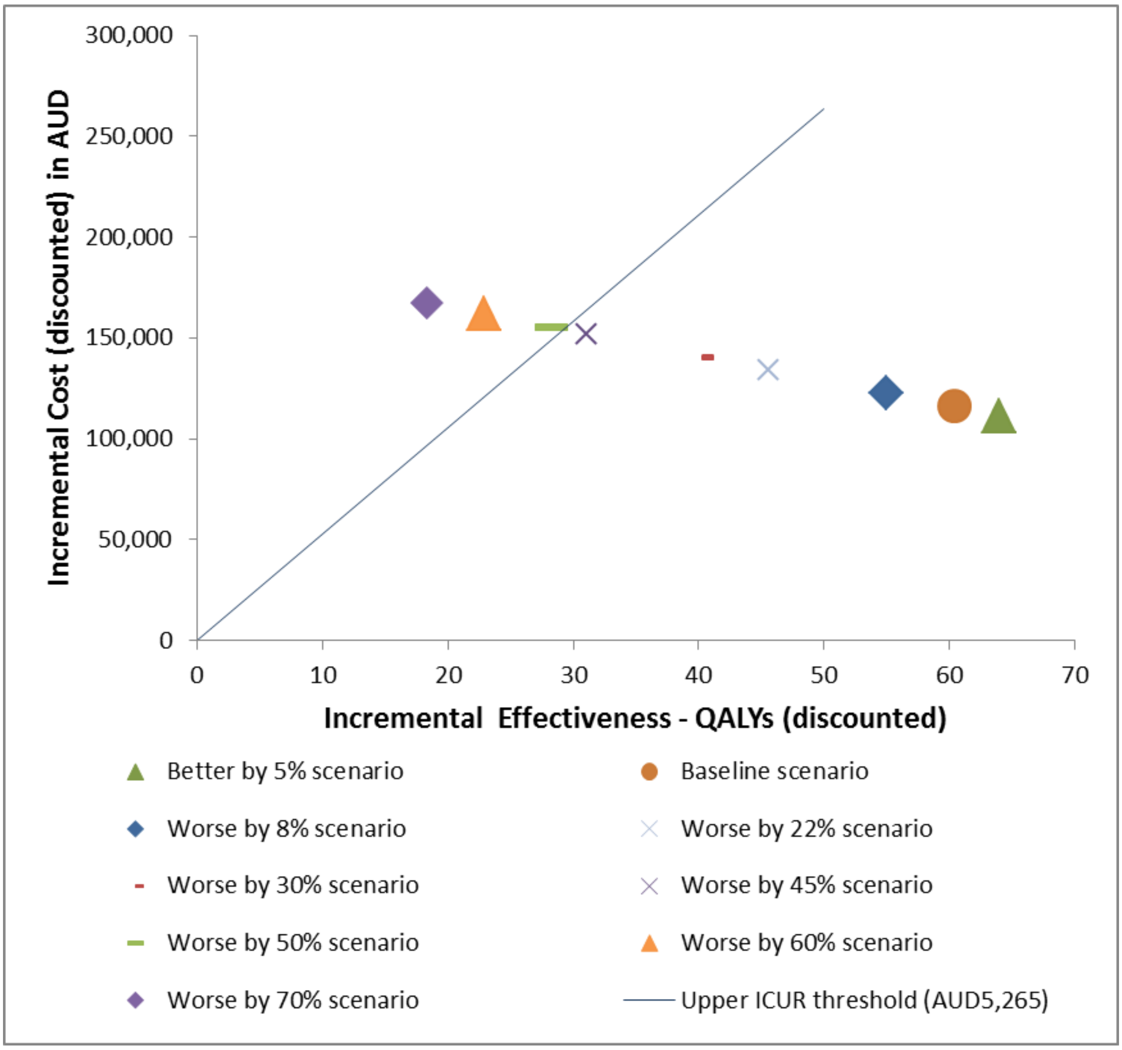


Figure 41: Sensitivity analysis of the ICER of intervention C compared to B for both males and females when the intervention effectiveness is changed – the Vietnam Government cost norm

The ICER of intervention level C compared to intervention level B calculating for the "worse by 50%" of effectiveness of the intervention lies above the ICER threshold line, indicating from that level of effectiveness, intervention level C would not be cost-effective compared to intervention B.

Table 35 summarises the probabilistic results for the willingness-to-pay threshold suggested by the WHO for Vietnam of AUD5,265.

Table 35: Results of the sensitivity analysis considering uncertainty for intervention effectiveness parameters for both males and females using the Vietnam Government cost-norm

Scenarios	**Intervention B vs. Intervention A**			**Intervention C vs. Intervention B**		
	Probability of B being cost-effective compared to A	**Incremental NMB** *(in AUD)*		**Probability of C being cost-effective compared to B**	**Incremental NMB** *(in AUD)*	
		Mean	**95% Credible Interval**		**Mean**	**95% Credible Interval**
Better by 5%	94.5%	597,424	(574,436; 620,412)	69.5%	234,107	(204,914; 263,301)
Baseline	93.0%	565,993	(543,181; 588,806)	66.8%	187,884	(158,111; 217,658)
Worse by 22%	80.3%	314,095	(291,165; 337,026)	57.4%	109,840	(79,238; 140,441)
Worse by 25%	79.1%	284,731	(261,328; 308,134)	56.5%	84,143	(53,841; 114,445)
Worse by 45%	60.6%	74,706	(52,358; 97,054)	51.4%	25,866	(-3,625; 55,358)
Worse by 50%	57.1%	44,346	(21,291; 67,401)	49.3%	-4,536	(-35,498; 26,425)
Worse by 55%	51.3%	-7,313	(-29,487; 14,861)	48.6%	-16,586	(-45,817; 12,645)
Worse by 60%	47.7%	-48,262	(-70,543; -25,982)	45.9%	-31,422	(-60,478; -2,367)

Results from the probabilistic analysis for different levels of effectiveness parameters also showed that the better level of effectiveness could result in the higher value of incremental net monetary benefit (NMB). Interestingly, the 95% incredible intervals of all examined scenarios except for "worse by 55%" scenario when comparing B to A, the 95% incredible intervals of all examined scenarios except for "worse by 45%, 50%, 55%" scenarios when comparing C to B did not span zero, indicating the certainty surrounding the decision.

7.4. Expected value of information analysis

The expected value of perfect information (EVPI) for the whole decision is assessed.

Using the Ford Foundation cost norm, for a ceiling ratio value of AUD5,265/QALY gained, the EVPI was valued at AUD152,152 for a group of 50,000 males, AUD71,486 for a group of 50,000 females and AUD215,000 for a total of 100,000 males and females. Figure 42 illustrates the EVPI for different willingness-to-pay thresholds. The relatively low value of perfect information at a ceiling ratio of λ = AUD5,265 suggested that the cost-effectiveness of the best choice under current information was already quite clear and not likely to change even under perfect information.

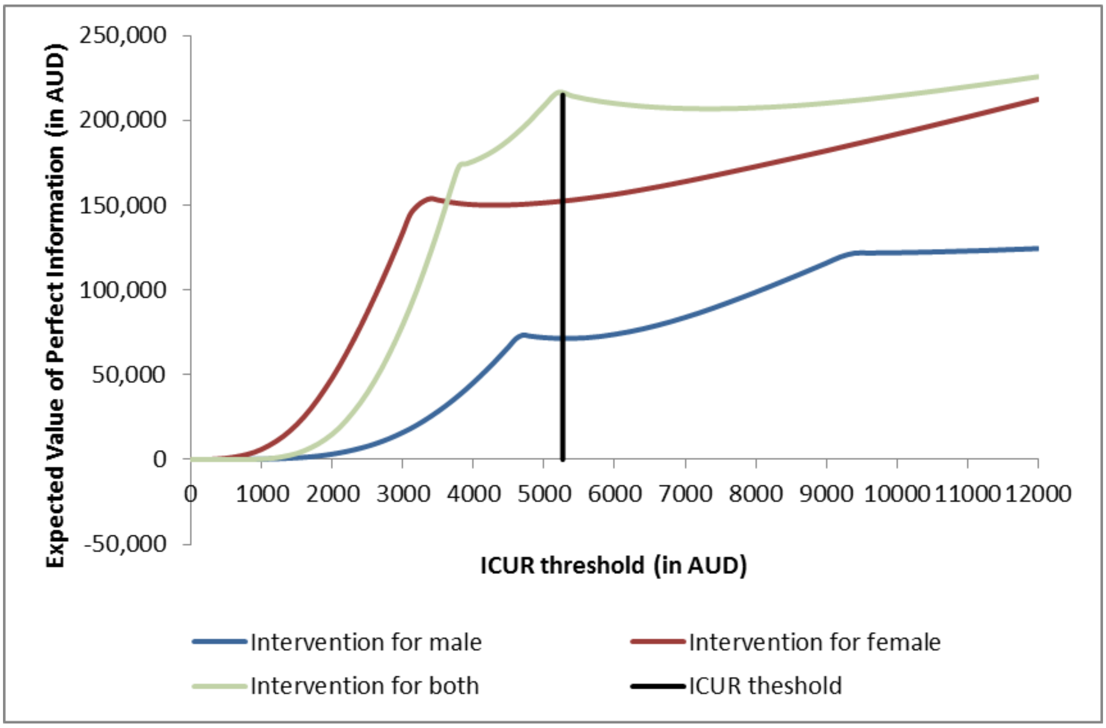


Figure 42: Expected value of perfect information for the overall decision – the Ford Foundation cost norm

Using the Vietnam Government cost norm, for a ceiling ratio value of AUD5,265/QALY gained, the EVPI was valued at AUD51,580 for a group of 50,000 males, AUD95,878 for a group of 50,000 females and AUD91,688 for a total of 100,000 males and females. Figure 43 illustrates the EVPI for different willingness-to-pay thresholds. The extremely low value of perfect information at a ceiling ratio of λ = AUD5,265 suggested that the cost-effectiveness of the best choice under current information was already quite clear and not likely to change even under perfect information.

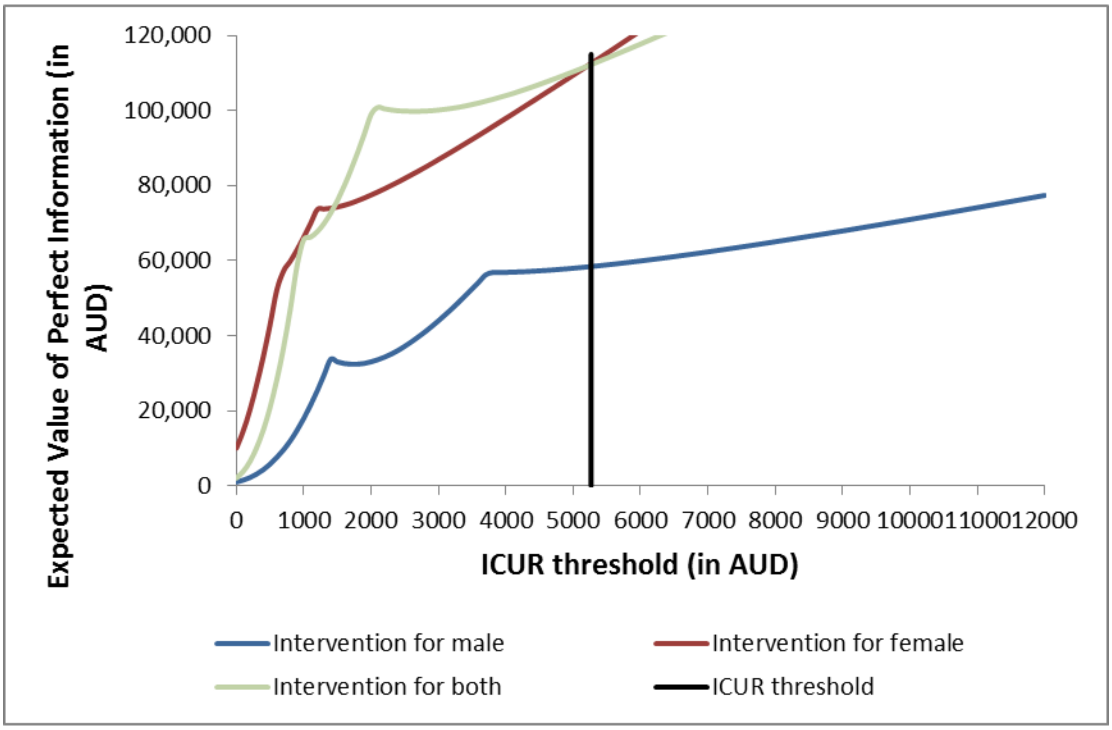


Figure 43: Expected value of perfect information for the overall decision – the Vietnam Government cost norm

7.5. Summary

The cost-effectiveness analysis evaluated two options:

(1) The existing level of reproductive health education programs for adolescents compared to education intervention level B which received both school-based and health facility-based components, **without** emphasis on transforming gender relations to promote gender equity

(2) Intervention level B compared to level C, which received school-based, community-based and health facility-based components, **with** emphasis on the transformation of gender relations to promote gender equity.

When using the Ford Foundation cost norm, the ***deterministic analysis*** found that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was cost-effective, while implementing intervention level C compared to level B was only cost-effective for females or the group of both male and female participants but not for males.

When using the Vietnam Government cost norm, the ***deterministic analysis*** revealed that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was highly cost-effective, while implementing intervention level C compared to level B was only highly cost-effective for females but cost-effective for males or the group of both male and female participants.

When ***uncertainty*** was considered, using the Ford Foundation cost norm, at the ceiling ratio of λ = AUD5,265, intervention level B for male, intervention level C for female adolescents and intervention level C for a group of both male and female adolescents had the highest probability of being cost-effective.

When ***uncertainty*** was considered, using the Vietnam Government cost norm, at the ceiling ratio of λ = AUD5,265, intervention level C was the option with the highest probability of having the largest net monetary benefit, either for males or females or a group of both male and female adolescents.

A range of ***scenario analyses*** with variations of effectiveness of the education intervention changed the final decision regarding the cost-effectiveness of the different levels of intervention. Using the Ford Foundation cost norm, intervention level B over A would no longer be a cost-effective option if the effectiveness parameters changed to "worse by 5%" for males, "worse by 35%" for females and "worse by 20%" for both male and female participants. Intervention level C in relation to B would no longer be cost-effective if the effectiveness parameters changed to "worse by 35%" for females and "worse by 5%" for both male and female participants.

Using the Vietnam Government cost norm, intervention level B over A would no longer be a cost-effective option if the effectiveness parameters changed to "worse by 45%" for males, "worse by 70%" for females and "worse by 60%" for both male and female participants. Intervention level C in relation to B would no longer be cost-effective if the effectiveness parameters changed to "worse by 20%" for males, “worse by 75%” for females and “worse by 50%” for both male and female participants.

As the optimal choice of intervention was highly certain, there was no value in collecting additional information, reflected in the relatively low value of perfect information.

Chapter 8 - Discussion

In this chapter, the results of the economic evaluation are summarised and interpreted (8.1). Both limitations (8.2) and strengths (8.3) of this research are highlighted. How these results can be applied to decision making in Vietnam is also discussed (8.4). The direction for future research is given (8.5) before the chapter concludes (8.6).

8.1. Interpretation of findings

The cost-effectiveness of three mutually exclusive education interventions was evaluated for a cohort of 50,000 male and 50,000 female adolescents, aged 13 years at baseline. Outcomes compared education intervention level B, which concerned both school-based and health facility -based components, **without** emphasis on transforming gender relations to promote gender equity to intervention level A, the existing level of reproductive health education program for adolescents. Following this, the idea of upgrading intervention level B to level C was further evaluated by comparing intervention level B with intervention level C, which received school-based, community-based and health facility-based components, **with** emphasis on transformation of gender relations to promote gender equity.

The results of ***deterministic analysis*** indicate that the education intervention is relatively low cost; therefore, if the effectiveness of the intervention is sustained, they are likely to be good value for money. According to WHO criteria, the cost-effectiveness is in the range AUD1,755 to AUD5,265 per QALY gained. When using the Ford Foundation cost norm, the deterministic analysis revealed that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was cost effective. The ICERs of intervention level B in relation to level A were AUD4,772/QALY gained, AUD2,988/QALY gained, AUD3,727/QALY gained for male students, female students and a group of both male and female students, respectively. Implementing intervention level C compared to level B was only cost-effective for females or the group of both male and female participants but not for males. The ICERs of intervention level C over level B were AUD8,521/QALY gained, AUD3,332/QALY gained and AUD4,995/QALY gained for male students, female students and both male and female students, respectively.

When using the Vietnam Government cost norm, the deterministic analysis revealed that implementing intervention level B compared to level A either for males or females or a group of both male and female participants was highly cost effective. The ICERs of intervention level B in relation to level A for male students, female students and a group of both male and female students were AUD1,375/QALY gained, AUD590/QALY gained and AUD915/QALY gained, respectively. Implementing intervention level C compared to level B was only highly cost-effective for females but cost-effective for males or the group of both male and female participants. The ICERs of intervention level C over level B for male adolescents, female adolescents and both male and female adolescents were AUD3,708/QALY gained, AUD1,064/QALY gained, and AUD1,911/QALY gained, respectively.

When uncertainty was taken into consideration, the outcomes of 1,000 model simulations re-enforced the deterministic findings regardless of whether the Ford Foundation or the Vietnam Government cost norms were used. The probability adoption was cost-effective expressed as the proportion of simulations where net monetary benefits were greater than zero, and this statistic was augmented with a 95% credible interval.

Using the Ford Foundation costs when compared to intervention A, implementation of intervention level B for male participants or female participants or both male and female participants was cost-effective in 59.4%, 69.2%, 70.5% of simulations. The 95% credible intervals of the NMB for males or females or both males and females did not span zero, indicating a high level of certainty for the adoption decision. When compared to intervention level B, implementation of intervention level C for female participants and both male and female participants was cost-effective in 55.0% and 50.7%, respectively, of simulations. However, for male participants, implementation of intervention level C was not a cost-effective option as the mean incremental NMB higher than zero in only 36.5% of simulations.

The 95% credible intervals of the NMB for males or females, but not for both males and females, did not span zero, indicating a high level of certainty for the adoption decision. At the ceiling ratio of λ = AUD5,265, implementation of education intervention level B for males, intervention level C for females and intervention level C for a group of both male and female adolescents had the highest probability of being cost-effective and the highest value of mean NMB. Compared to current practice, the expected mean incremental NMB achieved by the intervention was

AUD34,422 (level B, for male), AUD240,969 (level C, for female) and AUD201,429 (level C for both male and female participants).

Using the Vietnam Government costs, when compared to intervention A, implementation of intervention level B for male participants or female participants or both male and female participants was cost-effective in 90.8%, 85.8% and 93.0% of simulations. The 95% credible intervals of the NMB for males or females or both males and females did not span zero, indicating a high level of certainty for the adoption decision. When compared to intervention level B, implementation of intervention level C for male participants or female participants or both male and female participants was cost-effective in 57.8%, 64.9% and 66.8%, respectively, of simulations.

The 95% credible intervals of the NMB for males or females or both males and females did not span zero, indicating a high level of certainty for the adoption decision. In conclusion, at the ceiling ratio of λ = AUD5,265, intervention level C was the option with the highest probability of being cost-effective and highest value of mean NMB, either for male or female or a group of both male and female adolescents. Compared to current practice, the expected mean incremental NMB achieved by the intervention was AUD242,437 (level C, for male), AUD511,441 (level C for female) and AUD753,878 (level C for both male and female participants).

In the scenario analysis, the effectiveness of the education intervention was varied and the effect on outcomes was recorded. Using the Ford Foundation costs, intervention level B compared to A for male participants or female participants or both male and female participants remained cost-effective as the effectiveness of the education intervention improved, showing the model had face validity. Intervention level B over A would no longer be a cost-effective option if the effectiveness parameters changed to “worse by 5%” for males, “worse by 35%” for females, and “worse by 20%” for both male and female participants. Intervention level C in relation to B would no longer be cost-effective if the effectiveness parameters changed to “worse by 35%” for females and “worse by 5%” for both male and female participants, however, intervention level C over B for males would only be cost-effective if the effectiveness of the education intervention was “better by 40% or above”, even when the effectiveness was better by 30%, the intervention did not seem to be cost-effective. The scenario analysis showed that the variation range of effectiveness of education intervention level B or C for females, or level B for both males and females was wide enough for decision-makers to be confident that it would be a cost-effective choice. However, the variation range of effectiveness of education intervention level B or C for males, or intervention level C for both males and females was not wide enough for decision-makers to be confident about the cost-effectiveness of that choice.

In the scenario analysis, using the Vietnam Government costs, intervention level B compared to A for male participants or female participants or both male and female participants remained cost-effective as the effectiveness of the education intervention improved, showing that the model had face validity. Intervention level B over A would not be a cost-effective option if the effectiveness parameters changed to “worse by 45%” for males, “worse by 70%” for females and “worse by 60%” for both male and female participants. Intervention level C compared to B for male participants or female participants or both male and female participants remained cost-effective as the effectiveness of the education intervention improved or worsened. Intervention level C in relation to B would no longer be cost-effective if the effectiveness parameters changed to “worse by 20%” for males, “worse by 75%” for females and “worse by 50%” for both male and female participants. The scenario analysis showed that the variation range of effectiveness of the education intervention level B or C for males or females or both males and females was wide enough for decision-makers to be confident that it would be a cost-effective choice. However, the variation range of effectiveness of the education intervention for females was always wider than that of males, indicating that there was gender sensitivity in the reproductive health education intervention.

As the optimal choice of intervention was highly certain, there was no value in collecting additional information, reflected in the relatively low value of perfect information. Using the Ford Foundation costs, for a ceiling ratio value of AUD5,265/QALY gained, the EVPI was valued at AUD152,152 for a group of 50,000 males, AUD71,486 for a group of 50,000 females and AUD215,000 for a total of 100,000 males and females. Using the Vietnam Government costs, for a ceiling ratio value of AUD 5,265/QALY gained, the EVPI was valued at AUD51,580 for a group of 50,000 males, AUD95,878 for a group of 50,000 females and AUD91,688 for a total of 100,000 males and females. The extremely low value of perfect information at a ceiling ratio of λ = AUD5,265, whether using the Ford Foundation or the Vietnam Government costs, suggested that the cost-effectiveness of the best choice under current information was already quite clear and not likely to change even under perfect information.

The effectiveness of the interventions, when compared to other studies showed that the results from expert opinion elicitation have moderate values. For instance, a systematic review and meta-analysis of peer education interventions in developing countries published between January 1990 and November 2006 found that peer education interventions were significantly associated with increased HIV knowledge (OR: 2.28; 95% CI:1.88, 2.75) and increased condom use (OR:1.92; 95% CI:1.59, 2.33) (Medley et al., 2009). In this study in Vietnam, the expert opinion elicitation estimated an increase in condom use among sexually active adolescents (OR: 1.44; 95% CI: 1.38, 1.50 for males, intervention B versus A, OR: 1.56; 95%CI: 1.50, 1.62 for males, intervention C versus A, OR: 1.47; 95%CI: 1.41, 1.54 for females, intervention B versus A, OR: 1.68; 95%CI: 1.62, 1.75 for females, intervention C versus A) (part 6.5.2).

Comparing these findings to results from previous studies implemented in developed countries reveals that the education intervention in Chi Linh, Vietnam has a relatively low ICER; hence, the results appear promising and support investment. An economic evaluation (Pinkerton et al., 2000) of an intensive one-day sexual risk-reduction intervention for African-American males, designed to increase knowledge of HIV/AIDS (including correct condom use) and reduce risky sexual behaviours, was done by Pinkerton and colleagues in 2000. The authors reported the cost-utility ratio of approximately US$57,000 per QALY saved when training costs were included, and US$41,000 per QALY saved when they were excluded. The cost-utility ratio in Pinkerton's research was nearly 10 times higher than in this research when using the Ford Foundation costs, and nearly 30 times higher than in this research when using the Vietnam Government costs.

In 2008, Ateka and colleagues (2008) examined the cost-effectiveness of the city of Houston HIV/STD Prevention program, a school-based HIV/STD knowledge and sexual behaviour of public high school students and reported the base-case cost-utility ratio of US$32,755 per QALY saved for males and US$292,046 per QALY saved for females. Ateka's research showed different cost-utility ratios between interventions targeting males and females, in favour of males. Meanwhile, this study confirmed the different ICERs between interventions targeting males and females, but in favour of females. This might be due to the intervention in Chi Linh focusing on the gender issues and promoting a supportive environment that favoured female adolescents. Hence, the effectiveness of the intervention was much higher for females. Moreover, the cost utility ratio in Ateka's research was seven times higher than the cost utility ratio in this study for males when using the Ford Foundation costs and 23 times higher than that for males when using the Vietnam Government costs. When compared the cost utility ratios for females between Ateka's research and this study, the difference was a hundred times higher. These differences were not surprising given the wealth of literature on gender differences in sexual behaviours.

A recent economic evaluation by Cooper et al. (2012) included analysis of two types of school-based behavioural interventions, teacher-led and peer-led. Cooper and colleagues reported that compared to standard education, the incremental cost-effectiveness of teacher-led and peer-led interventions was €24,268 and €96,938 per QALY gained, respectively. The cost-utility ratio in Cooper's research was much higher than in this research when using either the Ford Foundation or the Vietnam Government costs. On the other hand, two studies (Rosenthal et al., 2009; L.Y. Wang et al., 2000) involved cost-effectiveness analysis using a net monetary benefit approach and reported the intervention net benefit of US$174,276 and US$559,677 for the whole intervention, or US$1599 per adolescent per year. The authors concluded that the intervention was cost-effective. The net monetary benefit of this research was not as high as that of Wang's or Rosenthal's studies due to the willingness-to-pay threshold in Vietnam being relatively low.

Comparison between this research and previous studies shows a wide range of cost-effectiveness estimates. There may be many reasons. First, the difference may be partly explained by the fact that Ateka (2008) and Pinkerton (2000) included the effects of the intervention on HIV (primary and secondary transmission) only. Rosenthal et al (2009) focused on the female teenagers' pregnancy and births only, while this study paid broad attention to the effects of intervention on HIV, other STIs (including chlamydia, gonorrhea, PID), unintended pregnancy, birth delivery and abortion.

Second, the different methods used to estimate the costs of intervention may result in differences between studies. For the calculation of the intervention costs, all previous studies (Ateka & Lairson, 2008; K. Cooper et al., 2012; Pinkerton et al., 2000; Rosenthal et al., 2009; L.Y. Wang et al., 2000) calculated the direct cost, not in-direct cost, while the current research included both costs from the intervention implementers' perspective and costs from the intervention participants' perspective. The previous studies calculated averted medical costs based on the standard of care recommended by an international panel (Pinkerton et al., 2000), borrowed from literature where available (L.Y. Wang et al., 2000) or used UK specific resource use and costing data where available (K. Cooper et al., 2012). However, in the current research the medical cost was calculated based on actual data from a survey of costs from patients and families' perspective and based on the price list of health care services for the cost from the health care providers' perspective.

Third, the different parameter values used may result in differences between studies. Wang and colleagues (2000) used an average HIV point prevalence of 0.002 in their calculation. Pinkerton and colleagues (2000) used the same HIV point prevalence among males and females in the community of 0.6% in their outcome estimation. Ateka and colleagues (2008) used an unadjusted HIV prevalence of 0.006 and an ethnicity-adjusted HIV prevalence of 0.054203 in their effect estimations. Cooper and colleagues (2012) used a wide range of HIV point prevalence estimates between 0.06% and 0.12% for female adolescents and between 0.13% and 0.26% for male adolescents. In contrast, in Vietnam, the HIV point prevalence was much lower, at 0.0014% for male adolescents and 0.00027% for female adolescents.

In addition to HIV infections, two studies included the effects of changes in sexual behaviour in terms of other STI infections averted. Wang and colleagues (2000) used an average chlamydia incidence rate of 0.078 and an average gonorrhea incidence rate of 0.006 in their calculation. Cooper and colleagues (2012) used a relatively wide range of other STIs point prevalence, between 0.16% and 12% for female adolescents, and between 0.03% and 1.5% for male adolescents. The current research STI point prevalence was much lower, 0.00915% for gonorrhea infections and 0.012% for chlamydia infections.

Wang and colleagues' study (2000) showed that for a cohort of 275,000 students, the number of pregnancy cases averted was 18.5. Rosenthal and colleagues (2009) showed that the teenage childbearing rate was reduced from 94.10 to 40.00 per 1000 teenage girls after the intervention. Cooper and colleagues (2012) found that for a cohort of 1000 girls aged 15 years, the number of pregnancy cases averted was 0.05 case compared to standard sex education. While the current research showed a moderate result that for a cohort of 50,000 girls aged 14 years, the number of pregnancy cases averted was 1.56 cases per year compared to current practice.

In comparison to other studies, the current research adapted relatively moderate input parameter values in order to avoid optimistically over-estimating the effects of the intervention. Subsequently, the final decision on cost-effectiveness of the intervention was not over-estimating. Pinkerton and colleagues (2000) estimated that the intervention resulted in a savings of 0.106 QALY over the assumed one year duration for a cohort of 85 participants. Ateka and colleagues (2008) reported the resultant number of 28.2 QALYs saved for each averted HIV infection. Cooper and colleagues (2012) calculated for a cohort of 1000 boys and 1000 girls aged 15 years, 0.35 QALYs would be saved by the intervention. The current research calculated that for a cohort of 50,000 males and 50,000 females, 11.83 QALYs would be saved by the intervention per year. Thus, the effectiveness parameters in this study were much lower than previous studies.

8.2. Limitations

This study has a number of limitations which should be addressed including method of analysis, economic model, input data for the model and assumptions made.

8.2.1. Method of analysis

Compared to the evaluation of clinical intervention, the evaluation of public health and health promotion interventions has particular challenges. For a clinical intervention, it is obvious to see the results of treatment as clear clinical endpoints, which can be specified and measured in experimental circumstances. This is not the case in health promotion or health education interventions, where the effects of the intervention cannot be observed clearly. It is especially true for reproductive health education intervention as the translation of effects of the intervention, such as increase in condom use; decrease in the number of sexual partners, into transition probabilities plays a key role for the method. This study adapted a modelling method used in previous cost-effectiveness studies of adolescent reproductive health education programs, especially HIV and unintended pregnancy prevention programs. Those previous programs were preventive and designed for targeting adolescents. The similarity between this education intervention and the previous programs made such method adaptation plausible.

8.2.2. Model structure

Results of model-based economic evaluations always rely on model structure. Models consider key events related to a decision problem and are never perfect, as they rely on a simplification of real events. For the structure of this model, several other reproductive health states were considered, for example, genital warts, hepatitis B; however, the probabilities of these pathways could not be identified due to the lack of data for Vietnam. Human papilloma virus infection was not included in the model because the literature did not show the clear effects of condom use or reducing number of sexual partners on preventing human papilloma virus infection. Finally, eleven health states were taken into consideration within this model. The number of health states included in the current research outnumbered those in previous studies. This exclusion is not expected to change overall outcomes as the main reproductive health states were included in the model structure.

8.2.3. Input parameters

Researchers often prefer evidence comparing the relevant alternatives to come from randomised controlled trials. However, only a few studies have been conducted in this field using a rigorous, randomised, controlled design, whereas others were natural experiments or were not randomised. This study was initially designed to use the quasi-experimental design with pre and post intervention evaluation of reproductive health knowledge and behaviours. The outcomes of pre and post intervention evaluation were expected to be available to use as the effectiveness parameters in this study, when the economic analysis was first proposed and during most of the PhD candidature. However, due to some unexpected difficulties, including personnel and finance issues, the post intervention evaluation has not yet been done. Therefore, the actual data from the intervention was not available to use; instead, the elicitation of expert opinion approach, the best available method, was adapted. In an effort to quantify the effects of this limitation on the final results, both Bayesian statistical techniques such as probabilistic sensitivity analysis and scenario analysis were undertaken. The model should be updated once the post intervention evaluation becomes available.

Additionally, regarding the expert elicitation on the effectiveness of such education interventions, although 14 experts participated; they may not represent the opinion of the majority of experts. Despite attempts to recruit a diverse sample of experts with direct experience in analysis of outcomes, it is possible some of them were over-optimistic about the benefits of educational interventions in the Vietnamese context, and this may cause bias. However, a bigger sample size seemed infeasible because there are few local experts with satisfactory level of experience in both health promotion (i.e. health education interventions) and reproductive health among adolescents. This limited the number of experts eligible for the study. In response to this limitation, scenario analysis on different values of effectiveness was undertaken intensively and showed that the findings from expert elicitation could vary in a wide range but did not change the final decisions on the cost-effectiveness of the education interventions.

Health care costs from a health care providers' perspective were calculated based on recently published cost calculations or health care service charges from Circular No. TTLT – 04 – BYT-BTC from the Vietnam Ministry of Health and Vietnam Ministry of Finance, rather than actual costs from actual health care patients. The published cost calculations included both direct and indirect costs, but the health care service charges consists of only direct costs associated with in-hospital treatment, and does not include indirect costs or overhead costs, e.g. running costs for hospital director board, administrative departments including accounting, planning or infection control departments. The use of health care service charges is therefore likely to understate real health care costs. If the health care costs were understated, the overall cost-effectiveness of education interventions would be underestimated. The health care costs were therefore given much attention in the uncertainty analysis and the result showed that this limitation was not expected to impact on the final results. Moreover, the indirect costs from the patients and family members, which was the productivity lost because of suffering ill-health states, were also not included in this analysis. This is due to the unavailability of this cost from literature in a Vietnamese context, and the complexity of this type of cost collection and calculation.

8.2.4. Model assumptions

Data used to build economic models are often scarce, especially in the Vietnamese context; therefore, several assumptions had to be made. First, an assumption of all heterosexual relations was made because same-sex sexual relations are not popular in Confusion culture, especially in Vietnam, thus no data exists for the percentage of adolescents who engage in same-sex sexual acts or the differential effectiveness of the intervention for those adolescents.

Second, it was assumed that males and females had independent risks of STDs based on the best available literature from population level studies; data were not available describing sexual interactions within the cohort. These data would have allowed for a more precise specification of the risk of acquiring an STD.

Third, for several parameters of the economic evaluation, there were no available data for the age-specific group, as data were often presented for the 14-25 year age group in national surveys, such as SAVY 1, SAVY 2 and WHO's report on adolescent reproductive health. In particular, current data on the sexual behaviour, HIV point prevalence and other STIs incidence rates was absent for this age-specific group. Therefore assumption was made in order to extrapolate data from the 14 to 25 age group. This extrapolation could result in overestimation of the incidence or point prevalence of the 14 year old group. This issue was overcome by tracking adolescents in the model for a long time period, 10 years for females and 14 years for males.

Fourth, data on model variables were limited. There were no empirical and local data directly available for some of the model variables, such as HIV point prevalence and other STD incidence rates of sexual partners of intervention students, the time duration required for the HIV infected people becoming aware of the infection; and how long they would live following HIV infection, the probability of choosing abortion following getting pregnant, and other variables. In these cases, several assumptions were made using available data from other settings or research, which in turn could result in overstating or understating the results.

Fifth, the duration of the intervention effectiveness is unknown; some research (Cohen, Wu, & Farley, 2004; K. Cooper et al., 2012) was based on the assumption of 1 year duration and the researchers included this point as one of the limitations of not being able to take into account long-term effects, therefore perhaps underestimating the impact (Cohen et al., 2004). They questioned whether the effectiveness could last for several years in the case of school-based interventions and confirmed the need for a more complicated model to simulate the epidemic of HIV and other STIs transmission (L.Y. Wang et al., 2000). On this basis, the current study included the assumption that the education intervention effects would last until primary intervention participants reached marriage age in Vietnam (10 year duration for females and 14 year duration for males) and a complicated model was involved in this study.

Sixth, regarding the uncertainty analysis, an assumption was made that decision-makers were risk neutral and focused on maximising net benefits. The decision rule on the cost-effectiveness of the intervention, therefore, was set to be more than 50% of the values of the NMB greater than zero. In reality, decision-makers tend to be risk averse, are going to be wary, and may require a higher probability of being cost-effective (Heitjan, Moskowitz, & Whang, 1999).

8.3. Strengths

This economic evaluation is one of the few examples of an assessment of the cost-effectiveness of adolescent reproductive health education interventions globally, and the first in Vietnam. All necessary assumptions, definitions and limitations were discussed.

Compared to the evaluation of clinical intervention, the outcome evaluation of educational interventions has particular difficulties. Doing a valid prospective study to measure these outcomes would be very complicated and expensive. Focusing on informing decision about adoption, the expert elicitation approach on the effectiveness of the educational intervention and a modelling study is an efficient alternative. Findings may not be as precise, but were done at a fraction of the cost and still provided useful, policy relevant outcomes.

In comparison to previous studies, this study was based on a more comprehensive model. It took into consideration not only HIV infection (including HIV (asymptomatic or untreated) and HIV (treated)), other STIs (including chlamydia (asymptomatic or untreated and treated), gonorrhea (asymptomatic or untreated and treated), PID), but also unintended pregnancy, birth delivery, abortion, post-delivery or post-abortion. It adapted the shortest possible cycle interval, only 3 months, in order to reflect the dynamic nature of reproductive health in adolescents. By using the age-specific underlying risk of mortality in each cycle, a time-dependent Markov process was used in this economic evaluation instead of the simple Markov process.

The best available evidence was used for the parameterisation of model inputs. The economic model was informed by high quality input parameters including primary data on intervention costs (costs from the intervention implementers' perspective and costs from the intervention participants' perspective), primary data on health care costs from health care patients and families' perspective, primary data on health related quality of life, adaptation of a methodology widely used in cost-effectiveness studies of adolescent reproductive health education intervention for the calculation of transition probabilities, and systematic searches for other input parameter data.

In contrast to previous studies, whereby the authors often assumed the same effect from different types of intervention (K. Cooper et al., 2012), the transition probabilities in this study were differentiated between males and females and between different levels of intervention. This difference makes this study more complicated but plausible as gender norms are widely assumed to affect adolescent attitudes, perceptions, and behaviour regarding sexual and reproductive health, the probability of acquiring reproductive health related problems is therefore different between males and females. Moreover, education intervention level C, which paid more attention to gender issues and covered community activities, should have resulted in better outcomes in comparison with the education intervention levels A and B.

The current research incorporated the impact of changes in health related quality of life to individuals from a total of 11 health states to present the outcomes in terms of cost per QALYs gained, commonly used by health decision makers. Few studies that have estimated the cost-effectiveness of interventions to prevent HIV and other STIs or unintended pregnant have used estimates of QALYs. Rather, other outcome measures such as cost per major outcome averted or cost per case avoided have been used. This type of outcome measurement decreases the comparability of these studies with other health interventions, and involves making assumptions such as assuming that all STIs have equal health consequences, which is unlikely to be the case. The process of valuing health related quality of life, subsequently QALYs in this study consists of several good points. First, it involved the use of a standardised and widely accepted multi-attribute questionnaire, EQ-5D. Second, descriptions for each health state were collected from the point of view of adolescents themselves. Third, it involved the use of the South Korean population-based preference weights for EQ-5D, proven to be culturally appropriate to use for Vietnam.

Furthermore, the uncertainty surrounding model parameters was evaluated in a complex Monte Carlo cohort simulation and the impact on the overall decision was measured. The results of the probabilistic analysis, scenario analysis and value of perfect information analysis showed the robustness of the decision model results.

8.4. Using this evidence for decision making in Vietnam

Until now, researchers and health promotion practitioners in Vietnam have relied heavily on ad hoc evidence from other countries to select adolescent reproductive health interventions. For instance, the education intervention in Chi Linh was designed based on lessons learnt from the Reproductive Health Initiative for Youth in Asia (RHIYA), which was funded by the European Union and implemented in seven Asian countries (Bangladesh, Cambodia, Laos, Nepal, Pakistan, Sri Lanka, and Vietnam). There remains a gap in evidence regarding the value of different intervention approaches. Economic aspects of the different interventions at least from intervention implementers' perspectives were not addressed in RHIYA and other previous programs. Yet, such cost data and cost-effective analysis is crucial for making informed decisions about replicating and scaling up successful programs in Vietnam. Additionally, using evidence from other countries neglects country-specific differences in both epidemiology data and actual needs of adolescents. Furthermore, gender equity was not clearly addressed and evaluated to provide useful lessons learnt for future adolescent reproductive health intervention programs. Clearly, this evidence is particularly important in the process of implementation of the "National Master Plan on Protection, Care, and Promotion of Adolescent and Youth Health for the Period 2006-2010 and Strategic Orientation until 2020" for Vietnam. For the first time, a decision model was used to incorporate and synthesise the highest level and most suitable information available for the Vietnamese context.

This study took into account two different cost-norms, therefore, the results should be applicable to the intervention provider team and local stake-holders when deciding whether to implement future interventions funded by international organisations or the Vietnam Government. In the last two decades, public health interventions in Vietnam have relied heavily on international development assistance, for example, financial and technical support from the Ford Foundation. However, Vietnam's transition to a low-middle-income economy has brought new challenges in shifting from international donor support to national funding. Consequently, the Vietnam Government cost norms will most likely be used for public health interventions in upcoming years.

Moreover, this economic evaluation was done with different groups in mind, which makes the results applicable to the intervention provider team and local stakeholders when choosing which level of intervention to implement for males and/or females or mixed gender groups. For both cost norms, the economic evaluations have confirmed the cost-effectiveness of implementing education intervention levels B and C for males only, for females only and for a group of both males and females in relation to level A. Using the Ford Foundation cost norm, implementing education intervention level B for different groups is cost-effective. Resource allocation can however be further improved by additional investing to upgrade to intervention level C for females and for a group of both males and females, but not for males. Using the Vietnam Government cost norm, implementing education intervention level B for different groups is highly cost-effective. Where resources are available, resource allocation can be further improved by additional investing to upgrade to intervention level C for all different groups.

8.5. Future research

The expected value of perfect information analysis was relatively low indicating little value in funding additional research to improve the quality of data for input parameters. Nevertheless, further areas of current evidence could be improved.

Future research should expand the model with other relevant reproductive health problems, in particular genital warts or hepatitis B. This would require the availability of both epidemiological data and evidence of effectiveness of treatment in order to calculate transition probabilities, preferably from high quality meta-analysis of RCTs.

The evidence of effectiveness of the education intervention was derived from the elicitation of expert opinions, in the future, if the actual data on effectiveness should be available from the post intervention evaluation, the decision model could be updated. However, it may not be necessary to implement a large and expensive trial to measure the effectiveness of the intervention. The scenario analysis on different values of effectiveness suggested that the final decision of the cost-effectiveness of the education interventions would hardly change given the wide variation range of the results from expert elicitation. Thus, there would be little value in collecting additional information.

Additionally, health care costs from health care providers' perspective in this study were not calculated based on actual health care costs from actual health care patients; therefore, it would be possible to re-collect and re-calculate these costs and update the final results.

As comprehensive age-specific data on sexual behaviours and reproductive health of adolescents is not available in Vietnam, researchers could pay attention to gathering these types of data, preferably from high quality meta-analysis of RCTs, which could assist further economic evaluations.

As existing evidence is not clear about the time duration for which the effectiveness of the reproductive health education intervention could last, future research should consider the possibility of evaluating and synthesising evidence on this topic.

Although the findings from cost-effectiveness analyses such as this study are very useful, researchers all over the world suggest it should not be the sole decision-making tools in determining the allocation of health care resources. Another interesting area of research would be to explore second stage filter criteria including ‘equity’, ‘strength of evidence’, ‘acceptability’, ‘feasibility’, ‘sustainability’, 'side-effects' and ‘replicability in the local area’ (Cohen et al., 2004; Drummond et al., 2005).

8.6. Conclusions

This study indicates the cost-effectiveness of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam. The results of the decision analytic model were discussed and limitations and strengths were outlined. The evidence ascertained was appropriately critiqued and was relevant to the intervention team and local stake-holders.

The direction for future research, such as updating the decision model with more health states related to reproductive health, updating the model with the actual data on effectiveness from the post-intervention evaluation once it is available, and paying more attention to evaluation and synthesising of evidence on the time duration of the effectiveness of the reproductive health education intervention were suggested.

Regarding the effectiveness measurement of the educational intervention, a large and expensive trial could be done. However, by focusing on informing decisions about adoption, the expert elicitation approach on the effectiveness of the educational intervention and a modelling study has proved to be an efficient alternative.

This thesis has added to the small amount of literature on educational interventions for adolescents from a health economics point of view. It is believed to be the first economic evaluation involving a decision modelling technique to incorporate and synthesise the highest level and most suitable information available for the Vietnamese context. The results of this study are expected to assist decision-makers to efficiently allocate scarce health resources. Current information suggests which level of reproductive health education intervention is cost-effective and should be expanded to other areas for different cost-norms and for different gender groups of adolescents. Based on this evidence, if the decision-makers, including the intervention team, Ministry of Health and Ministry of Education and Training, change their current practice of approaching and educating adolescents on reproductive health to the best option, costs would be incurred at the lowest amount and health benefits would be brought back to the highest level. Moreover, this study is expected to show researchers and intervention implementers in other settings how to address similar questions.

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Appendices

Appendix 1 – Searching strategies (chapter 4)

	Description	Key words	Database
Stage 1	The first attempt at the search in which a limited set of key words was used to find potentially relevant studies. These studies were reviewed in an effort to expand key words and phrases for a more in-depth search	"*adolescent reproductive health program*" OR "*youth reproductive health interventions*" AND "*cost effective analysis*" OR "*health technology assessment*"	PubMed, Google Scholar, Google, Cochrane, PsychINFO , Psychnet, CINAHL, OVID medline (R) Scopus, DEBI
Stage 2	Expanded the databases used and searched using the full list of key words developed in Stage 1	Keywords in stage 1 and: "*health education intervention*", "*school age children*", "*school students*", "*unwanted pregnancy*", "*abortion*", "*STDs*", "*HIV/AIDS*", "*Chlamydia*", "*Gonorrhea*", "*PID*", "*quality-adjusted life-years (QALY)*", "*disability-adjusted life-years (DALY)*", "*number of cases avoided*", "*cost-utility analysis*", "*modelling*", "*RCTs*"	PubMed, Cochrane CENTRAL, AMED ASSIA, Science and Social Sciences Citation Indexes, EMBASE, ERIC, HMIC, PsychINFO, Psychnet, Research findings electronic register (ReFeR), Database of Abstracts of Reviews of Effectiveness (DARE)
Stage 3	Involving searching the reference lists of identified articles for any relevant references and hand searching appropriate journals. Making decision of expanding or narrowing the search. Conducting author search on the names of authors known to have conducted research on the review objective	Key words using in stage 2 And searching for author name	PubMed, Cochrane Grey literature: Include professional organizations relevant to the review objective to search for reports, guidelines, unpublished research, e.g., WHO, World Bank Hand searches of journals and proceeding of major related conferences

Appendix 2 – Characteristic of education intervention and economic evaluation studies (chapter 4)

Studies	Economic evaluation type	Perspective	Time horizon	Model cohort (for model and health outcome measurement)
Cooper et al. (2012)	CUA	The UK National Health Services and Personal Social Services	1 year	1,000 boys and 1,000 girls aged 15 years old
Rosenthal et al. (2009)	CEA using a monetary net benefit approach	Societal	Intervention: 7-year To estimate program cost–benefit up to age 30 years	50 students
Ateka et al. (2007)	CUA	A third party payer	Life-time	Three intervention schools were randomly selected from a list of 17 participating schools
Pinkerton et al. (2000)	CUA	Societal	1 year	157 African American male adolescents, mean age = 14.64 years (72 in control group and 85 in intervention group)
Wang et al. (2000)	CEA using a monetary net benefit approach	Societal	1 year	Outcome measurement: 3677 ninth-grade students who completed the baseline and first follow-up surveys

Studies	Country	Intervention participants	Intervention type	Intervention contents
Cooper et al. (2012)	UK	4,063 pupils (aged 15 years old), 463 peer educators, and fourteen schools	2 school-based behavioural interventions: teacher-led and peer-led	The teacher-led intervention: 20 sessions, involved active learning (small group work and games), information leaflets on sexual health, and development of skills, primarily using interactive video and role-playing. The peer-led intervention: 3 sessions led by peer educators lasting 1 hour each, over one school term. The sessions covered relationships, STIs, and use of condoms and contraception
Rosenthal et al. (2009)	The United States	Boys and girls aged 11–18 years from the Arch Street area	A community-based participatory research approach	Six integrated components to boys and girls: (1) education about family life, sex, and health; (2) academic support, including tutoring and weekly monitoring of progress; (3) career and vocational preparation; (4) artistic expression; (5) recreation; (6) physical and mental healthcare referrals.
Ateka et al. (2007)	The United States	Students grades 9 to 12	School-based HIV/STD knowledge and sexual behaviour	Participants in the program learn about HIV/AIDS, other sexually transmitted diseases, and safer sexual practices such as condom use. Participants in the control group attended regular health classes, which covered HIV/AIDS and STDs
Pinkerton et al. (2000)	The United States	African American male adolescents	School-based program	An intensive, 1-day sexual risk reduction intervention, to increase participant's knowledge of HIV/AIDS (including correct condom use) and to weaken problematic attitudes toward risky sexual behaviour. The intervention used videotapes, games, exercises and other culturally and developmentally appropriate materials to convey information in an engaging and entertaining manner
Wang et al. (2000)	The United States	10 schools in northern California and 10 schools in southeast Texas	School-based education program	Designed to prevent HIV, other STDs, and pregnancy among high school students. Safer Choices is a 2-year, theory-based, multi-component intervention, an evaluation of which was implemented during the 1993-1994 and 1994-1995 school years. The primary aim of it is to reduce the number of students engaging in unprotected sexual intercourse. The program focuses on school-wide change to influence student behaviour.

Appendix 3 – Methods used within the eligible economic evaluation studies (chapter 4)

Studies	Estimation of Costs	Estimation of Effects	Deterministic analysis/Result
Cooper et al. (2012)	Estimated the costs of education interventions based upon the resources used in the SHARE and RIPPLE trials. Limited data were available from both the teams, so most of the resources were estimated by systematically extracting data from the study publications, without any inflation adjustment stated	**Method**: Adopted the Bernoulli statistical model **Unit measurement**: total number of STI cases averted (for ex: the number of cases averted for HIV, chlamydia, gonorrhea, and genital warts), consequent quality adjusted life-year (QALY) gain	**Cost-utility ratio**: $R = (C - AT)/AQ.$ **Result:** The teacher-led intervention: ICER €24,268 per QALY gained compared with standard sex education The peer-led behavioural intervention ICER of €96,938 per QALY gained compared with standard sex education
Rosenthal et al. (2009)	The average annual operating costs of the program from 1997 to 2003, including salaries and benefits for admin and program staff, rent and utilities, maintenance, food, expenses for fundraising activities, the establishment and maintenance of the onsite work experience and training program, and other miscellaneous costs. All costs were in December 2006 dollars	Total societal benefits included the sum of (1) the total costs averted from prevention of the estimated number of births to teenage girls that would have occurred without the program; and (2) the additional economic benefits from participating, independent from prevention of births. It was assumed that the opportunity cost of participation was $0; because there are otherwise few wage earning and enrichment activities available locally, the young people lost leisure time only	**Net benefit equation**: $\text{Net Benefit}_{intervention} = (C_{averted} + B_{intervention}) - C_{intervention}$ **Result:** The total operating costs exceeded economic benefits by $559,677.05 during the program years, or $1,599.08 per teenager. In the extrapolation analysis program, net benefits were estimated to be $10,474.77 per program participant by the time they reach age 30 years.

Studies	Estimation of Costs	Estimation of Effects	Deterministic analysis/Result
Ateka et al. (2007)	Estimated the direct cost of the program, including personnel, reimbursement of the community-based organizations (CBOs) that implemented the program, office space, supplies, transport, and equipment. All costs were based on 2005 expenditures	**Method**: Adopted the Bernoulli statistical model A self-administered questionnaire was used for eliciting data from the sample size of 430 students. The knowledge section of the questionnaire was an aptitude test on the subject material covered under the program. The rest of the questionnaire was questions on sexual behaviour.	**Cost-utility ratio**: R = (C − AT)/AQ. **Result:** The base-case cost-utility ratio of \$32,755 per QALY saved for male and \$292,046 per QALY saved for female
Pinkerton et al. (2000)	Intervention costs, including personnel costs, transportation costs, material cost, facilities costs, and incentives for participants, were ascertained retrospectively. All costs were in 1997 US dollars	**Method**: Adopted the Bernoulli statistical model Participants in both the intervention and control conditions completed detailed sexual behaviour inventories at baseline and 3 month-follow up	**Cost-utility ratio**: R = (C − AT)/AQ. **Result:** The cost-utility ratio was approximately \$57,000 U.S. per QALY saved when training costs were included, and \$41,000 U.S. per QALY saved when they were excluded
Wang et al. (2000)	Included program costs, the costs of condoms and oral contraceptives, and medical and social costs averted by prevention. All costs were in 1994 dollars	**Method**: Adopted the Bernoulli statistical model (to translate the increase in condom use into cases of HIV and other STDs averted), developed a pregnancy model to translate contraceptive use into cases of pregnancy averted	**Net benefit equation** $\text{Net Benefit}_{\text{intervention}} = (C_{\text{averted}} + B_{\text{intervention}}) - C_{\text{intervention}}$ **Result:** The results of base-case analysis. The **net benefit** was \$174276, and the **benefit-cost ratio** was 2.65. HIV indicates human immunodeficiency syndrome; PID,

Studies	Uncertainty analysis	Cost-effectiveness threshold	Authors' conclusions
Cooper et al. (2012)	**Method**: Model uncertainty using probabilistic sensitivity analyses: The parameters were varied according to the ranges used in the deterministic sensitivity analysis. **Result**: The teacher-led intervention had an ICER between €0 and €36,000 per QALY for 48% of iterations, >€36,000 per QALY for 28% of iterations. For 24% of iterations, the intervention was associated with a QALY loss. The peer-led intervention had a corresponding lower likelihood of being cost-effectiveness, an ICER between €0 and €36,000 per QALY for 16% of iterations	For the UK NHS, an intervention with a cost-effectiveness ratio less than £30,000 (€36,000) per QALY is generally considered to be cost-effective	There was uncertainty around the results due to the limited effect of the intervention on behavioural outcomes and paucity of data for other input parameters
Rosenthal et al. (2009)	**Method**: Key variables were varied (number of students, proportion female, expected pregnancy rates for nonparticipants and participants, average age of childbearing, annual program costs, and discount rate for future benefits). **Result**: In sensitivity analysis, total social benefits would outweigh total social costs by reaching age 20.1 years	Net benefit >0	This comprehensive teenage pregnancy prevention program is estimated to provide societal economic benefits once participants are young adults
Ateka et al. (2007)	**Method**: The ratios were then varied based on 3 scenarios (base, worst, and best case scenario). Finally, the ratios were varied based on discount rates of 0%, 3%, and 5% **Result**: The program was cost saving for female and cost-effective for male participants when ethnicity adjusted HIV prevalence was used with the assumption of best-case scenario. It remained cost-effective for female but not for male participants in the base case scenario.	The convention of considering health service programs, with cost−utility-ratios between $30,000 and $140,000 per QALY saved as cost-effective	The program achieved significant risk reduction in HIV infection, particularly among female participants, on a relatively low budget

Studies	Uncertainty analysis	Cost-effectiveness threshold	Authors’ conclusions
Pinkerton et al. (2000)	**Method**: Sensitivity analyses on all parameters to assess how uncertainty in these parameters affected the main result were conducted (Discount rate at 0%, 3%, 5%)	Cost utility ratios that are less than $40,000 to $60,000/QALY saved are cost-effective, whereas those whose CUEs exceed $180,000 per QALY are of questionable cost-effectiveness	The HIV prevention intervention was moderately cost-effective in comparison with other health care programs
Wang et al. (2000)	**Method**: Multivariable sensitivity analysis. The parameters were varied according to the ranges used in the deterministic sensitivity analysis. **Result**: Results of most of the scenarios remained cost saving under a wide range of model variable estimates. over a reasonable range of 6 variable estimates: probability of HIV and other STD transmission, HIV point prevalence, STD incidence rates, condom use per act, contraceptive failure rate, percentage of students using contraceptives, and medical cost per case	Net benefit >0	The results of our study suggest that the Safer Choices program can be delivered at a reasonable cost and that it is cost-effective and cost saving in most scenarios considered

Appendix 4 – Input parameter of Markov model

Name	***Description***
Quarterly Transition probabilities	
P1	Probability transition from Healthy to Healthy (remain Healthy)
P2	Probability transition from Healthy to Abortion
P3	Probability transition from Healthy to Giving birth
P4	Probability transition from Healthy to HIV (Asymptomatic or untreated)
P5	Probability transition from Healthy to HIV (Treated)
P6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)
P7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)
P8	Probability transition from Healthy to Treated acute STDs
P9	Probability transition from Healthy to Deceased
P10	Probability transition from Abortion to Healthy
P11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)
P12	Probability transition from Abortion to Post-abortion/delivery
P13	Probability transition from Abortion to Deceased
P14	Probability transition from Giving birth to Healthy
P15	Probability transition from Giving birth to Giving birth (opt to carry but not yet delivery)
P16	Probability transition from Giving birth to Post-abortion/delivery
P17	Probability transition from Giving birth to Deceased
P18	Probability transition from Post-abortion/delivery to Healthy
P19	Probability transition from Post-abortion/delivery to Post-abortion/delivery
P20	Probability transition from Post-abortion/delivery to Deceased
P21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)
P22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)

Name	***Description***
P23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased
P24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)
P25	Probability transition from HIV (Treated) to Deceased
P26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy
P27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs
P28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID
P29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased (other causes mortality, not due to STDs)
P30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy
P31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs
P32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID
P33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased (other causes mortality, not due to STDs)
P34	Probability transition from Treated STDs to Healthy
P35	Probability transition from Treated STDs to PID
P36	Probability transition from Treated STDs to Deceased
P37	Probability transition from PID to Healthy
P38	Probability transition from PID to PID (remain with PID)
P39	Probability transition from PID to Deceased
P40	Probability transition from Deceased to Deceased, remain Deceased
Mor	Age-specific mortality rate of Vietnam
Effectiveness parameters for prior elicitation	
PPa	Incidence of having premarital sexual intercourse among adolescents in site A
PPb	Incidence of having premarital sexual intercourse among adolescents, site B
PPc	Incidence of having premarital sexual intercourse among adolescents, site C
PCa	Proportion of using condom among sexually active adolescents in site A

Name	Description
PCb	Proportion of using condom among sexually active adolescents in site B
PCc	Proportion of using condom among sexually active adolescents in site C
PSa	Proportion of using condom properly among sexually active adolescents in site A
PSb	Proportion of using condom properly among sexually active adolescents in site B
PSc	Proportion of using condom properly among sexually active adolescents in site C
NIa	Average number of sexual episodes for the last 3 months among sexually active adolescents in site A
Nib	Average number of sexual episodes for the last 3 months among sexually active adolescents in site B
Nic	Average number of sexual episodes for the last 3 months among sexually active adolescents in site C
NPa	Average number of partners per sexually active adolescent within the last 3 months in site A
NPb	Average number of partners per sexually active adolescent within the last 3 months in site B
NPc	Average number of partners per sexually active adolescent within the last 3 months in site C
Utility scores of different health states involved in the Model	
U1	Utility score for being Healthy
U2	Utility score for having Abortion
U3	Utility score for Giving birth
U4	Utility score for Post-abortion/delivery
U5	Utility score for having HIV (Asymptomatic or untreated)
U6	Utility score for having HIV (Treated)
U7	Utility score for having Gonorrhea (Asymptomatic or Untreated)
U8	Utility score for having Chlamydia (Asymptomatic or Untreated)
U9	Utility score for having Treated STDs
U10	Utility score for having PID
U11	Utility score for being death

Name	*Description*
Costing parameters	
	Ford Foundation cost norm
C1AF	Direct intervention cost in site A
C1BF	Direct intervention cost in site B
C1CF	Direct intervention cost in site C
C2AF	Indirect intervention costs (Intervention participant costs), site A
C2BF	Indirect intervention costs (Intervention participant costs), site B
C2CF	Indirect intervention costs (Intervention participant costs), site C
	Vietnam Government cost norm
C1AV	Direct intervention cost in site A
C1BV	Direct intervention cost in site B
C1CV	Direct intervention cost in site C
C2AV	Indirect intervention costs (Intervention participant costs), site A
C2BV	Indirect intervention costs (Intervention participant costs), site B
C2CV	Indirect intervention costs (Intervention participant costs), site C
B1.1	Direct treatment costs for being Healthy (=0)
B2.1	Indirect treatment costs for being Healthy (=0)
B1.2	Direct treatment costs for Abortion
B2.2	Indirect treatment costs for Abortion
B1.3	Direct treatment costs for Giving birth
B2.3	Indirect treatment costs for Giving birth
B1.4	Direct treatment costs for Giving birth
B2.4	Indirect treatment costs for Giving birth
B1.5	Direct treatment costs for HIV (Asymptomatic or Untreated)
B2.5	Indirect treatment costs for HIV (Asymptomatic or Untreated)
B1.6	Direct treatment costs for HIV (Treated)
B2.6	Indirect treatment costs for HIV (Treated)

Name	***Description***
B1.7	Direct treatment costs for Gonorrhea (Asymptomatic or Untreated)
B2.7	Indirect treatment costs for Gonorrhea (Asymptomatic or Untreated)
B1.8	Direct treatment costs for Chlamydia (Asymptomatic or Untreated)
B2.8	Indirect treatment costs for Chlamydia (Asymptomatic or Untreated)
B1.9.1	Direct treatment costs for Gonorrhea
B2.9.1	Indirect treatment costs for Gonorrhea
B1.9.2	Direct treatment costs for Chlamydia
B2.9.2	Indirect treatment costs for Chlamydia
B1.10	Direct treatment costs for PID
B2.10	Indirect treatment costs for PID
B1.11	Direct treatment costs for being death
B2.11	Indirect treatment costs for being death
Other parameters	
R1	Quarterly discount rate for costs (%)
R2	Quarterly discount rate for benefits (%)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
Male	**No intervention (site A)**							
	Probability transition from not sexually active to sexually active	**0.0221**	**0.0222**	**0.0221**	**0.0223**	**22,079.24**	**977,920.76**	Beta (α,β)
PAM1	Probability transition from Healthy to Healthy (remain Healthy)	0.9985	0.9984	0.9985	997,167.7600	998,455.39	1,544.61	Dirichlet (α1,α2,..αk)
PAM2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	5.6673	3.18	999,996.82	Dirichlet (α1,α2,..αk)
PAM5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	0.5653	0.75	999,999.25	Dirichlet (α1,α2,..αk)
PAM6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0003	0.0003	0.0003	321.1850	310.52	999,689.48	Dirichlet (α1,α2,..αk)
PAM7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0005	0.0005	0.0005	487.5391	459.82	999,540.18	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAM8	Probability transition from Healthy to Treated acute STDs	0.0008	0.0007	0.0008	744.1873	770.34	999,229.66	Dirichlet (α1,α2,..αk)
PAM9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM10	Probability transition from Abortion to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM12	Probability transition from Abortion to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM13	Probability transition from Abortion to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM14	Probability transition from Giving birth to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM16	Probability transition from Giving birth to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM17	Probability transition from Giving birth to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAM18	Probability transition from Post-abortion/delivery to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8073	0.8075	807,423.2827	807,478.63	192,521.37	Dirichlet (α1,α2,..αk)
PAM22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1895	0.1892	189,499.0979	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)
PAM23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0032	0.0033	3,228.0916	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)
PAM24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PAM25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAM26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.4500	0.4506	0.4500	450,687.4217	450,000.00	550,000.00	Dirichlet (α1,α2,..αk)
PAM27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.5000	0.4995	0.5000	499,593.1747	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)
PAM28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.0500	0.0499	0.0500	49,886.5880	50,000.00	950,000.00	Dirichlet (α1,α2,..αk)
PAM29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4000	0.4003	0.4000	400,494.9376	400,000.00	600,000.00	Dirichlet (α1,α2,..αk)
PAM31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.5000	0.4996	0.5000	499,824.0795	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)
PAM32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.1000	0.1001	0.1000	100,106.5529	100,000.00	900,000.00	Dirichlet (α1,α2,..αk)
PAM33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAM34	Probability transition from Treated STDs to Healthy	0.8750	0.8745	0.8750	875,105.5740	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PAM35	Probability transition from Treated STDs to PID	0.1250	0.1255	0.1250	125,582.2205	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PAM36	Probability transition from Treated STDs to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM37	Probability transition from PID to Healthy	0.9350	0.9352	0.9350	934,127.8875	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PAM38	Probability transition from PID to PID, remain PID	0.0650	0.0648	0.0650	64,686.3468	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PAM39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAM40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000		1,000,000.00	0.00	Deterministic
Female	**No intervention (site A)**							
	Probability transition from not sexually active to sexually active	**0.0195**	**0.0193**	**0.0195**	**0.0194**	**19,473.08**	**980,526.92**	Beta (α,β)
PAF1	Probability transition from Healthy to Healthy (remain Healthy)	0.9963	0.9962	0.9963	996,143.2114	996,293.33	3,706.67	Dirichlet (α1,α2,..αk)
PAF2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	23.3062	25.82	999,974.18	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAF3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	9.3886	8.61	999,991.39	Dirichlet (α1,α2,..αk)
PAF4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	8.2453	7.69	999,992.31	Dirichlet (α1,α2,..αk)
PAF5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	1.4760	1.80	999,998.20	Dirichlet (α1,α2,..αk)
PAF6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0013	0.0013	0.0013	1,289.8870	1,279.99	998,720.01	Dirichlet (α1,α2,..αk)
PAF7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0017	0.0017	0.0017	1,746.6802	1,650.21	998,349.79	Dirichlet (α1,α2,..αk)
PAF8	Probability transition from Healthy to Treated acute STDs	0.0007	0.0007	0.0007	700.2716	732.55	999,267.45	Dirichlet (α1,α2,..αk)
PAF9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF10	Probability transition from Abortion to Healthy	0.5914	0.5918	0.5914	592,106.2493	591,417.30	408,582.70	Dirichlet (α1,α2,..αk)
PAF11	Probability transition from Abortion to Abortion	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF12	Probability transition from Abortion to Post-abortion/delivery	0.4083	0.4080	0.4083	408,234.2232	408,349.31	591,650.69	Dirichlet (α1,α2,..αk)
PAF13	Probability transition from Abortion to Deceased	0.0002	0.0002	0.0002	229.5456	233.39	999,766.61	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAF14	Probability transition from Giving birth to Healthy	0.1676	0.1676	0.1676	167,690.3453	167,648.29	832,351.71	Dirichlet (α1,α2,..αk)
PAF15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.7164	0.7159	0.7164	716,163.7841	716,364.08	283,635.92	Dirichlet (α1,α2,..αk)
PAF16	Probability transition from Giving birth to Post-abortion/delivery	0.1158	0.1163	0.1158	116,306.0965	115,754.24	884,245.76	Dirichlet (α1,α2,..αk)
PAF17	Probability transition from Giving birth to Deceased	0.0002	0.0002	0.0002	247.2776	233.39	999,766.61	Dirichlet (α1,α2,..αk)
PAF18	Probability transition from Post-abortion/delivery to Healthy	0.0328	0.0325	0.0328	32,501.3765	32,782.97	967,217.03	Dirichlet (α1,α2,..αk)
PAF19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.9672	0.9675	0.9672	967,217.6530	967,188.78	32,811.22	Dirichlet (α1,α2,..αk)
PAF20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	35.4284	28.25	999,971.75	Dirichlet (α1,α2,..αk)
PAF21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8079	0.8075	807,911.5920	807,478.63	192,521.37	Dirichlet (α1,α2,..αk)
PAF22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1888	0.1892	188,803.6274	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAF23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0033	0.0033	3,268.9564	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)
PAF24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PAF25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)
PAF26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.6400	0.6405	0.6400	640,332.8467	640,000.00	360,000.00	Dirichlet (α1,α2,..αk)
PAF27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.2000	0.1997	0.2000	199,675.9686	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)
PAF28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.1600	0.1597	0.1600	159,670.9632	160,000.00	840,000.00	Dirichlet (α1,α2,..αk)
PAF29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased (Other causes death rate)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4800	0.4806	0.4800	479,413.9759	480,000.00	520,000.00	Dirichlet (α1,α2,..αk)
PAF31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.2000	0.2001	0.2000	199,598.4696	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PAF32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.3200	0.3193	0.3200	318,566.5875	320,000.00	680,000.00	Dirichlet (α1,α2,..αk)
PAF33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF34	Probability transition from Treated STDs to Healthy	0.8750	0.8752	0.8750	873,958.1546	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PAF35	Probability transition from Treated STDs to PID	0.1250	0.1248	0.1250	124,679.4406	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PAF36	Probability transition from Treated STDs to Deceased (other causes mortality, not due to STDs)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF37	Probability transition from PID to Healthy	0.9350	0.9353	0.9350	935,642.3335	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PAF38	Probability transition from PID to PID, remain PID	0.0650	0.0647	0.0650	64,679.3242	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PAF39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PAF40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
Male	Intervention (site B - School component)							
	Probability transition from not sexually active to sexually active	0.0193	0.0192	0.0193	0.0192	19,257.61	980,742.39	Beta (α,β)
PBM1	Probability transition from Healthy to Healthy (remain Healthy)	0.9989	0.9989	0.9989	1,000,454.2609	998,915.93	1,084.07	Dirichlet (α1,α2,..αk)
PBM2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	1.7254	2.19	999,997.81	Dirichlet (α1,α2,..αk)
PBM5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	0.0005	0.51	999,999.49	Dirichlet (α1,α2,..αk)
PBM6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0002	0.0002	0.0002	208.1127	217.45	999,782.55	Dirichlet (α1,α2,..αk)
PBM7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0003	0.0003	0.0003	324.2680	323.23	999,676.77	Dirichlet (α1,α2,..αk)
PBM8	Probability transition from Healthy to Treated acute STDs	0.0005	0.0006	0.0005	582.9021	540.68	999,459.32	Dirichlet (α1,α2,..αk)
PBM9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBM10	Probability transition from Abortion to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM12	Probability transition from Abortion to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM13	Probability transition from Abortion to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM14	Probability transition from Giving birth to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM16	Probability transition from Giving birth to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM17	Probability transition from Giving birth to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM18	Probability transition from Post-abortion/delivery to Healthy	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBM20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8070	0.8075	806,615.7823	807,478.63	192,521.37	Deterministic
PBM22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1896	0.1892	189,542.5583	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)
PBM23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0033	0.0033	3,333.9106	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)
PBM24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PBM25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)
PBM26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.4500	0.4489	0.4500	449,054.5534	450,000.00	550,000.00	Dirichlet (α1,α2,..αk)
PBM27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.5000	0.5010	0.5000	501,132.0038	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBM28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.0500	0.0501	0.0500	50,166.2212	50,000.00	950,000.00	Dirichlet (α1,α2,..αk)
PBM29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4000	0.4010	0.4000	401,386.5590	400,000.00	600,000.00	Dirichlet (α1,α2,..αk)
PBM31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.5000	0.4996	0.5000	500,059.4567	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)
PBM32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.1000	0.0994	0.1000	99,473.1330	100,000.00	900,000.00	Dirichlet (α1,α2,..αk)
PBM33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM34	Probability transition from Treated STDs to Healthy	0.8750	0.8754	0.8750	874,749.3713	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PBM35	Probability transition from Treated STDs to PID	0.1250	0.1246	0.1250	124,549.0048	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PBM36	Probability transition from Treated STDs to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBM37	Probability transition from PID to Healthy	0.9350	0.9350	0.9350	934,764.0629	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PBM38	Probability transition from PID to PID, remain PID	0.0650	0.0650	0.0650	64,954.1093	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PBM39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBM40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic
Female	**Intervention (site B - no gender emphasizing)**							
	Probability transition from not sexually active to sexually active	**0.0171**	**0.0170**	**0.0171**	**0.0174**	**17,066.89**	**982,933.11**	Beta (α,β)
PBF1	Probability transition from Healthy to Healthy (remain Healthy)	0.9970	0.9970	0.9970	995,225.2009	997,015.35	2,984.65	Dirichlet (α1,α2,..αk)
PBF2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	27.6257	21.36	999,978.64	Dirichlet (α1,α2,..αk)
PBF3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	7.5622	7.12	999,992.88	Dirichlet (α1,α2,..αk)
PBF4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	5.4878	6.03	999,993.97	Dirichlet (α1,α2,..αk)
PBF5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	0.0513	1.41	999,998.59	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBF6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0010	0.0010	0.0010	1,046.8291	1,029.76	998,970.24	Dirichlet (α1,α2,..αk)
PBF7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0013	0.0013	0.0013	1,331.9212	1,329.22	998,670.78	Dirichlet (α1,α2,..αk)
PBF8	Probability transition from Healthy to Treated acute STDs	0.0006	0.0006	0.0006	579.2460	589.75	999,410.25	Dirichlet (α1,α2,..αk)
PBF9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF10	Probability transition from Abortion to Healthy	0.5914	0.5915	0.5914	591,901.6188	591,417.30	408,582.70	Dirichlet (α1,α2,..αk)
PBF11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF12	Probability transition from Abortion to Post-abortion/delivery	0.4083	0.4082	0.4083	408,484.1957	408,349.31	591,650.69	Dirichlet (α1,α2,..αk)
PBF13	Probability transition from Abortion to Deceased	0.0002	0.0002	0.0002	234.9618	233.39	999,766.61	Dirichlet (α1,α2,..αk)
PBF14	Probability transition from Giving birth to Healthy	0.1676	0.1676	0.1676	167,330.9395	167,648.29	832,351.71	Dirichlet (α1,α2,..αk)
PBF15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.7164	0.7168	0.7164	715,835.4625	716,364.08	283,635.92	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBF16	Probability transition from Giving birth to Post-abortion/delivery	0.1158	0.1154	0.1158	115,208.1437	115,754.24	884,245.76	Dirichlet (α1,α2,..αk)
PBF17	Probability transition from Giving birth to Deceased	0.0002	0.0002	0.0002	228.6381	233.39	999,766.61	Dirichlet (α1,α2,..αk)
PBF18	Probability transition from Post-abortion/delivery to Healthy	0.0328	0.0328	0.0328	32,826.9214	32,782.97	967,217.03	Dirichlet (α1,α2,..αk)
PBF19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.9672	0.9672	0.9672	968,334.8123	967,188.78	32,811.22	Dirichlet (α1,α2,..αk)
PBF20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	27.5936	28.25	999,971.75	Dirichlet (α1,α2,..αk)
PBF21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8072	0.8075	806,226.6236	807,478.63	192,521.37	Dirichlet (α1,α2,..αk)
PBF22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1894	0.1892	189,142.3981	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)
PBF23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0034	0.0033	3,416.4495	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBF24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PBF25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)
PBF26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.6400	0.6398	0.6400	640,236.1694	640,000.00	360,000.00	Dirichlet (α1,α2,..αk)
PBF27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.2000	0.1998	0.2000	199,969.0756	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)
PBF28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.1600	0.1604	0.1600	160,502.6132	160,000.00	840,000.00	Dirichlet (α1,α2,..αk)
PBF29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4800	0.4799	0.4800	479,035.8461	480,000.00	520,000.00	Dirichlet (α1,α2,..αk)
PBF31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.2000	0.2003	0.2000	199,886.0438	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)
PBF32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.3200	0.3198	0.3200	319,225.6420	320,000.00	680,000.00	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PBF33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF34	Probability transition from Treated STDs to Healthy	0.8750	0.8750	0.8750	875,068.6620	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PBF35	Probability transition from Treated STDs to PID	0.1250	0.1250	0.1250	124,992.8362	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PBF36	Probability transition from Treated STDs to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF37	Probability transition from PID to Healthy	0.9350	0.9353	0.9350	934,825.3407	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PBF38	Probability transition from PID to PID, remain PID	0.0650	0.0647	0.0650	64,660.0137	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PBF39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PBF40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic
Male	**Intervention (site C - Comprehensive component, gender emphasizing)**							
	Probability transition from not sexually active to sexually active	**0.0183**	**0.0185**	**0.0183**	**0.0182**	**18,317.07**	**981,682.93**	Beta (α,β)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCM1	Probability transition from Healthy to Healthy (remain Healthy)	0.9991	0.9991	0.9991	999,235.8585	999,077.16	922.84	Dirichlet (α1,α2,..αk)
PCM2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	1.1797	1.85	999,998.15	Dirichlet (α1,α2,..αk)
PCM5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	0.4586	0.43	999,999.57	Dirichlet (α1,α2,..αk)
PCM6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0002	0.0002	0.0002	185.5429	184.96	999,815.04	Dirichlet (α1,α2,..αk)
PCM7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0003	0.0003	0.0003	273.0734	275.31	999,724.69	Dirichlet (α1,α2,..αk)
PCM8	Probability transition from Healthy to Treated acute STDs	0.0005	0.0005	0.0005	474.8132	460.28	999,539.72	Dirichlet (α1,α2,..αk)
PCM9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM10	Probability transition from Abortion to Healthy	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCM11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM12	Probability transition from Abortion to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM13	Probability transition from Abortion to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM14	Probability transition from Giving birth to Healthy	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic
PCM15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM16	Probability transition from Giving birth to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM17	Probability transition from Giving birth to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM18	Probability transition from Post-abortion/delivery to Healthy	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic
PCM19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCM20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8075	0.8075	807,692.1228	807,478.63	192,521.37	Deterministic
PCM22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1892	0.1892	189,238.9363	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)
PCM23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0033	0.0033	3,298.0112	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)
PCM24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PCM25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)
PCM26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.4500	0.4506	0.4500	450,590.9119	450,000.00	550,000.00	Dirichlet (α1,α2,..αk)
PCM27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.5000	0.4994	0.5000	499,459.0974	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCM28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.0500	0.0500	0.0500	49,976.1530	50,000.00	950,000.00	Dirichlet (α1,α2,..αk)
PCM29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4000	0.4003	0.4000	399,808.9848	400,000.00	600,000.00	Dirichlet (α1,α2,..αk)
PCM31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.5000	0.5002	0.5000	499,622.4612	500,000.00	500,000.00	Dirichlet (α1,α2,..αk)
PCM32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.1000	0.0996	0.1000	99,449.0016	100,000.00	900,000.00	Dirichlet (α1,α2,..αk)
PCM33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM34	Probability transition from Treated STDs to Healthy	0.8750	0.8748	0.8750	874,201.7614	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PCM35	Probability transition from Treated STDs to PID	0.1250	0.1252	0.1250	125,093.2241	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PCM36	Probability transition from Treated STDs to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCM37	Probability transition from PID to Healthy	0.9350	0.9349	0.9350	935,696.9032	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PCM38	Probability transition from PID to PID, remain PID	0.0650	0.0651	0.0650	65,153.4568	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PCM39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCM40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic
Female	**Intervention (site C - Comprehensive component, gender emphasizing)**							
	Probability transition from not sexually active to sexually active	**0.0158**	**0.0159**	**0.0158**	**0.0156**	**15,778.32**	**984,221.68**	Beta (α,β)
PCF1	Probability transition from Healthy to Healthy (remain Healthy)	0.9974	0.9975	0.9974	997,287.2791	997,385.99	2,614.01	Dirichlet (α1,α2,..αk)
PCF2	Probability transition from Healthy to Abortion	0.0000	0.0000	0.0000	12.1673	19.23	999,980.77	Dirichlet (α1,α2,..αk)
PCF3	Probability transition from Healthy to Giving birth	0.0000	0.0000	0.0000	6.1300	6.41	999,993.59	Dirichlet (α1,α2,..αk)
PCF4	Probability transition from Healthy to HIV (Asymptomatic or untreated)	0.0000	0.0000	0.0000	4.9460	4.97	999,995.03	Dirichlet (α1,α2,..αk)
PCF5	Probability transition from Healthy to HIV (Treated)	0.0000	0.0000	0.0000	2.2222	1.16	999,998.84	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCF6	Probability transition from Healthy to Gonorrhea (Asymptomatic or Untreated)	0.0009	0.0008	0.0009	833.1788	901.21	999,098.79	Dirichlet (α1,α2,..αk)
PCF7	Probability transition from Healthy to Chlamydia (Asymptomatic or Untreated)	0.0012	0.0012	0.0012	1,176.2461	1,164.58	998,835.42	Dirichlet (α1,α2,..αk)
PCF8	Probability transition from Healthy to Treated acute STDs	0.0005	0.0005	0.0005	499.3852	516.45	999,483.55	Dirichlet (α1,α2,..αk)
PCF9	Probability transition from Healthy to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF10	Probability transition from Abortion to Healthy	0.5914	0.5916	0.5914	591,378.0727	591,417.30	408,582.70	Dirichlet (α1,α2,..αk)
PCF11	Probability transition from Abortion to Abortion (pregnancy unknown then still not yet abort)	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF12	Probability transition from Abortion to Post-abortion/delivery	0.4083	0.4082	0.4083	408,041.3816	408,349.31	591,650.69	Dirichlet (α1,α2,..αk)
PCF13	Probability transition from Abortion to Deceased	0.0002	0.0002	0.0002	230.8043	233.39	999,766.61	Dirichlet (α1,α2,..αk)
PCF14	Probability transition from Giving birth to Healthy	0.1676	0.1679	0.1676	167,812.2732	167,648.29	832,351.71	Dirichlet (α1,α2,..αk)
PCF15	Probability transition from Giving birth to Giving birth (opt to carry and not yet delivery)	0.7164	0.7158	0.7164	715,621.8603	716,364.08	283,635.92	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCF16	Probability transition from Giving birth to Post-abortion/delivery	0.1158	0.1161	0.1158	116,065.6044	115,754.24	884,245.76	Dirichlet (α1,α2,..αk)
PCF17	Probability transition from Giving birth to Deceased	0.0002	0.0002	0.0002	206.0552	233.39	999,766.61	Dirichlet (α1,α2,..αk)
PCF18	Probability transition from Post-abortion/delivery to Healthy	0.0328	0.0327	0.0328	32,685.0789	32,782.97	967,217.03	Dirichlet (α1,α2,..αk)
PCF19	Probability transition from Post-abortion/delivery to Post-abortion/delivery	0.9672	0.9673	0.9672	968,123.0744	967,188.78	32,811.22	Dirichlet (α1,α2,..αk)
PCF20	Probability transition from Post-abortion/delivery to Deceased	0.0000	0.0000	0.0000	32.3332	28.25	999,971.75	Dirichlet (α1,α2,..αk)
PCF21	Probability transition from HIV(Asymptomatic or Untreated) to HIV (Asymptomatic or Untreated), remain HIV (Asymptomatic or Untreated)	0.8075	0.8073	0.8075	807,352.4217	807,478.63	192,521.37	Dirichlet (α1,α2,..αk)
PCF22	Probability transition from HIV (Asymptomatic or Untreated) to HIV (treated)	0.1892	0.1894	0.1892	189,396.8669	189,188.25	810,811.75	Dirichlet (α1,α2,..αk)
PCF23	Probability transition from HIV (Asymptomatic or Untreated) to Deceased	0.0033	0.0033	0.0033	3,312.3523	3,333.13	996,666.87	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCF24	Probability transition from HIV (Treated) to HIV (Treated), remain HIV (Treated)	0.9997	0.9997	0.9997	0.9997	999,666.69	333.31	Beta (α,β)
PCF25	Probability transition from HIV (Treated) to Deceased	0.0003	0.0003	0.0003	0.0003	333.31	999,666.69	Beta (α,β)
PCF26	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Healthy	0.6400	0.6390	0.6400	638,071.4611	640,000.00	360,000.00	Dirichlet (α1,α2,..αk)
PCF27	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Treated acute STDs	0.2000	0.2008	0.2000	200,462.4260	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)
PCF28	Probability transition from Gonorrhea (Asymptomatic or Untreated) to PID	0.1600	0.1602	0.1600	159,997.5190	160,000.00	840,000.00	Dirichlet (α1,α2,..αk)
PCF29	Probability transition from Gonorrhea (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF30	Probability transition from Chlamydia (Asymptomatic or Untreated) to Healthy	0.4800	0.4803	0.4800	479,727.1000	480,000.00	520,000.00	Dirichlet (α1,α2,..αk)
PCF31	Probability transition from Chlamydia (Asymptomatic or Untreated) to Treated Acute STDs	0.2000	0.1999	0.2000	199,695.4470	200,000.00	800,000.00	Dirichlet (α1,α2,..αk)
PCF32	Probability transition from Chlamydia (Asymptomatic or Untreated) to PID	0.3200	0.3198	0.3200	319,393.7929	320,000.00	680,000.00	Dirichlet (α1,α2,..αk)

Symbol	Input parameters	Live (Quarterly)	Probabilistic	Point estimate (Quarterly Transition probability)	Random draw	Alpha (Events)	Beta (Complement)	Type of distribution
PCF33	Probability transition from Chlamydia (Asymptomatic or Untreated) to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF34	Probability transition from Treated STDs to Healthy	0.8750	0.8750	0.8750	875,268.5870	875,000.00	125,000.00	Dirichlet (α1,α2,..αk)
PCF35	Probability transition from Treated STDs to PID	0.1250	0.1250	0.1250	125,084.6597	125,000.00	875,000.00	Dirichlet (α1,α2,..αk)
PCF36	Probability transition from Treated STDs to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF37	Probability transition from PID to Healthy	0.9350	0.9350	0.9350	937,188.4179	935,000.00	65,000.00	Dirichlet (α1,α2,..αk)
PCF38	Probability transition from PID to PID, remain PID	0.0650	0.0650	0.0650	65,184.2460	65,000.00	935,000.00	Dirichlet (α1,α2,..αk)
PCF39	Probability transition from PID to Deceased	0.0000	0.0000	0.0000	0.0000	0.00	1,000,000.00	Deterministic
PCF40	Probability transition from Deceased to Deceased, remain Deceased	1.0000	1.0000	1.0000	1,000,000.0000	1,000,000.00	0.00	Deterministic

Appendix 5 – Transition matrix of different analysis scenarios

Transition matrix for Male adolescents

Male	*Healthy*	*Abortion*	*Giving birth*	*Post-abortion/ delivery*	*HIV (Asymptomatic or Untreated)*	*HIV (Treated)*	*Gonorrhea (Asymptomatic or Untreated)*	*Chlamydia (Asymptomatic or Untreated)*	*STDs treated*	*PID*	*Deceased*
Healthy	***P1***	***0***	***0***	***0***	***P4***	***P5***	***P6***	***P7***	***P8***	***0***	***P9***
Abortion	***P10***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P13***
Giving birth	***P14***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P17***
Post-abortion/ delivery	***P18***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P20***
HIV (Asymptomatic or Untreated)	***0***	***0***	***0***	***0***	***P21***	***P22***	***0***	***0***	***0***	***0***	***P23***
HIV (Treated)	***0***	***0***	***0***	***0***	***0***	***P24***	***0***	***0***	***0***	***0***	***P25***
Gonorrhea (Asymptomatic or Untreated)	***P26***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P27***	***P28***	***P29***
Chlamydia (Asymptomatic or Untreated)	***P30***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P31***	***P32***	***P33***
STDs (treated)	***P34***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P35***	***P36***
PID	***P37***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P38***	***P30***
Deceased	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P40 (= 1)***

Transition matrix for Female adolescents

Female	***Healthy***	***Abortion***	***Giving birth***	***Post – abortion/ delivery***	***HIV (Asymptomatic or Untreated)***	***HIV (Treated)***	***Gonorrhea (Asymptomatic or Untreated)***	***Chlamydia (Asymptomatic or Untreated)***	***STDs treated***	***PID***	***Deceased***
Healthy	***P1***	***P2***	***P3***	***0***	***P4***	***P5***	***P6***	***P7***	***P8***	***0***	***P9***
Abortion	***P10***	***P11***	***0***	***P12***	***0***	***0***	***0***	***0***	***0***	***0***	***P13***
Giving birth	***P14***	***0***	***P15***	***P16***	***0***	***0***	***0***	***0***	***0***	***0***	***P17***
Post – abortion/delivery	***P18***	***0***	***0***	***P19***	***0***	***0***	***0***	***0***	***0***	***0***	***P20***
HIV (Asymptomatic or Untreated)	***0***	***0***	***0***	***0***	***P21***	***P22***	***0***	***0***	***0***	***0***	***P23***
HIV (Treated)	***0***	***0***	***0***	***0***	***0***	***P24***	***0***	***0***	***0***	***0***	***P25***
Gonorrhea (Asymptomatic or Untreated)	***P26***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P27***	***P28***	***P29***
Chlamydia (Asymptomatic or Untreated)	***P30***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P31***	***P32***	***P33***
STDs (treated)	***P34***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P35***	***P36***
PID	***P37***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P38***	***P30***
Deceased	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***P40 (= 1)***

Appendix 6 – Hierarchy of data sources used in economic models

Adopted from Cooper and colleagues (2005)

Rank	Data components
A	***Clinical effect sizes, adverse events and complications***
1+	Meta-analysis of RCTs with direct comparison between comparator therapies, measuring final outcomes
1	Single RCT with direct comparison between comparator therapies, measuring final outcomes
2+	Meta-analysis of RCTs with direct comparison between comparator therapies, measuring surrogate outcomes Meta-analysis of placebo-controlled RCTs with similar trial populations, measuring final outcomes for each individual therapy
2	Single RCT with direct comparison between comparator therapies, measuring surrogate outcomes Single placebo-controlled RCTs with similar trial populations, measuring the final outcomes for each individual therapy
3+	Meta-analysis of placebo-controlled RCTs with similar trial populations, measuring the surrogate outcomes
3	Single placebo-controlled RCTs with similar trial populations, measuring the surrogate outcomes for each individual therapy
4	Case control or cohort studies
5	Non-analytic studies, for example, case reports, case series
6	Expert opinion
B	***Baseline clinical data***
1	Case series or analysis of reliable administrative databases specifically conducted for the study covering patients solely from the jurisdiction of interest
2	Recent case series or analysis of reliable administrative databases covering patients solely from the jurisdiction of interest
3	Recent case series or analysis of reliable administrative databases covering patients solely from another jurisdiction
4	Old case series or analysis of reliable administrative databases. Estimates from RCTs
5	Estimates from previously published economic analyses: unsourced
6	Expert opinion
C	***Resource use***
1	Prospective data collection or analysis of reliable administrative data for specific study
2	Recently published results of prospective data collection or recent analysis of reliable administrative data – same jurisdiction
3	Unsourced data from previous economic evaluations – same jurisdiction
4	Recently published results of prospective data collection or recent analysis of reliable administrative data – different jurisdiction
5	Unsourced data from previous economic evaluation – different jurisdiction
6	Expert opinion

D	***Costs***
1	Cost calculations based on reliable databases or data sources conducted for specific study – same jurisdiction
2	Recently published cost calculations based on reliable databases or data course – same jurisdiction
3	Unsourced data from previous economic evaluation – same jurisdiction
4	Recently published cost calculations based on reliable databases or data sources – different jurisdiction
5	Unsourced data from previous economic evaluation – different jurisdiction
6	Expert opinion
E	***Utilities***
1	Direct utility assessment for the specific study from a sample either: (a) Of the general population (b) With knowledge of the disease(s) of interest (c) Of patients with the disease(s) of interest Indirect utility assessment from specific study from patient sample with disease(s) of interest, using a tool validated for the patient population
2	Indirect utility assessment from a patient sample with disease(s) of interest, using a tool not validated for the patient population
3	Direct utility assessment from a previous study from a sample either: (a) Of the general population (b) With knowledge of the disease(s) of interest (c) Of patients with the disease(s) of interest Indirect utility assessment from previous study from patient sample with disease(s) of interest, using a tool validated for the patient population
4	Unsourced utility data from previous study – method of elicitation unknown
5	Patient preference values obtained from a visual analogue scale
6	Delphi panels, expert opinion

Appendix 7 – Macros used to record the results of the Monte Carlo simulations

(Modified based on the Macros provided by Briggs et al.(2006b))

Part 1: Probabilistic sensitivity analysis

```
Sheets("Data-input on Cost").Select
Range("C3").Select
ActiveCell.FormulaR1C1 = "1"
Sheets("Data-input on Consequence").Select
Range("C3").Select
ActiveCell.FormulaR1C1 = "1"
Sheets("Uncertainty analysis").Select
Dim Index
Dim Trials
Index = 0
Trials = 1000

Do

Range("B5:NU5").Select
Selection.Copy
Range("B7:NU7").Select
ActiveCell.Offset(Index, 0).Range("A1").Select
Selection.PasteSpecial Paste:=xlPasteValuesAndNumberFormats, Operation:= _
   xlNone, SkipBlanks:=False, Transpose:=False
Index = Index + 1
Application.StatusBar = "Uncertainty analysis " & Index & " of 1000 trials"
      Loop While Index < Trials
Application.DisplayStatusBar = False
Sheets("Data-input on Cost").Select
Range("C3").Select
ActiveCell.FormulaR1C1 = "0"
  Sheets("Data-input on Consequence").Select
Range("C3").Select
ActiveCell.FormulaR1C1 = "0"

Sheets("Uncertainty analysis").Select
Range("A1").Select

End Sub
```

Part 2: Calculating the cost-effectiveness acceptability curves

```
Application.DisplayStatusBar = True
Sheets("Uncertainty analysis").Select
Dim Index
Dim Trials
Index = 0
Trials = 85
Do

    Range("PF7").Select
    ActiveCell.Offset(Index, 0).Range("A1").Select
    Selection.Copy
    Range("NY2").Select
    ActiveSheet.Paste
    Range("ON5:PE5").Select
    Application.CutCopyMode = False
    Selection.Copy
    Range("PG7").Select
    ActiveCell.Offset(Index, 0).Range("A1").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
        Index = Index + 1
    Application.StatusBar = "Calculation " & Index & " of " & Trials

Loop While Index < Trials
Application.DisplayStatusBar = False
Sheets("Uncertainty analysis").Select
Range("NY2").Select
ActiveCell.FormulaR1C1 = "5266"
End Sub
```

Part 3: Calculating the expected value of perfect information associated with the decision

```
Application.DisplayStatusBar = True
Sheets("Uncertainty analysis").Select
Dim Index As Integer
Dim Trials As Integer
Index = 0
Trials = 85

Do

    Range("QH7").Select
    ActiveCell.Offset(Index, 0).Range("A1").Select
    Selection.Copy
    Range("NY2").Select
    ActiveSheet.Paste
    Range("PZ2:QB2").Select
    Application.CutCopyMode = False
    Selection.Copy
    Range("QI7:QK7").Select
    ActiveCell.Offset(Index, 0).Range("A1").Select
    Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone, SkipBlanks:= _
        False, Transpose:=False
        Index = Index + 1
    Application.StatusBar = "Calculation " & Index & " of " & Trials

Loop While Index < Trials

Application.DisplayStatusBar = False
Sheets("Uncertainty analysis").Select
Range("NY2").Select
ActiveCell.FormulaR1C1 = "5266"

End Sub
```

Appendix 8 – Queensland University of Technology Human ethics approval certificate

QUT

University Human Research Ethics Committee

HUMAN ETHICS APPROVAL CERTIFICATE

NHMRC Registered Committee Number EC00171

Date of Issue: 12/4/13 (supersedes all previously issued certificates)

Dear Mrs Quynh Anh Nguyen

A UHREC should clearly communicate its decisions about a research proposal to the researcher and the final decision to approve or reject a proposal should be communicated to the researcher in writing. This Approval Certificate serves as your written notice that the proposal has met the requirements of the *National Statement on Research involving Human Participation* and has been approved on that basis. You are therefore authorised to commence activities as outlined in your proposal application, subject to any specific and standard conditions detailed in this document.

Within this Approval Certificate are:

* Project Details
* Participant Details
* Conditions of Approval (Specific and Standard)

Researchers should report to the UHREC, via the Research Ethics Coordinator, events that might affect continued ethical acceptability of the project, including, but not limited to:

(a) serious or unexpected adverse effects on participants; and
(b) proposed significant changes in the conduct, the participant profile or the risks of the proposed research.

Further information regarding your ongoing obligations regarding human based research can be found via the Research Ethics website http://www.research.qut.edu.au/ethics/ or by contacting the Research Ethics Coordinator on 07 3138 2091 or ethicscontact@qut.edu.au

If any details within this Approval Certificate are incorrect please advise the Research Ethics Unit within 10 days of receipt of this certificate.

Project Details

Category of Approval: Human non-HREC

Approved From: 11/04/2013 **Approved Until:** 11/04/2016 (subject to annual reports)

Approval Number: 1300000139

Project Title: Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam

Experiment Summary: An economic analysis of a reproductive health education intervention in Hai Duong province, northern Vietnam.

Investigator Details

Chief Investigator: Mrs Quynh Anh Nguyen

Other Staff/Students:

Investigator Name	**Type**	**Role**
Prof Nicholas Graves	Internal	Supervisor
Prof Michael Dunne	Internal	Supervisor
Dr Thanh Huong Nguyen	External	Supervisor

Participant Details

Participants:
Approximately 280

Location/s of the Work:
QUT and Vietnam

RM Report No. E801 Version 4

Page 1 of 2

University Human Research Ethics Committee

HUMAN ETHICS APPROVAL CERTIFICATE

NHMRC Registered Committee Number EC00171

Date of Issue: 12/4/13 (supersedes all previously issued certificates)

Conditions of Approval

Specific Conditions of Approval:
None apply

Standard Conditions of Approval:
The University's standard conditions of approval require the research team to:

1. Conduct the project in accordance with University policy, NHMRC / AVCC guidelines and regulations, and the provisions of any relevant State / Territory or Commonwealth regulations or legislation;

2. Respond to the requests and instructions of the University Human Research Ethics Committee (UHREC);

3. Advise the Research Ethics Coordinator immediately if any complaints are made, or expressions of concern are raised, in relation to the project;

4. Suspend or modify the project if the risks to participants are found to be disproportionate to the benefits, and immediately advise the Research Ethics Coordinator of this action;

5. Stop any involvement of any participant if continuation of the research may be harmful to that person, and immediately advise the Research Ethics Coordinator of this action;

6. Advise the Research Ethics Coordinator of any unforeseen development or events that might affect the continued ethical acceptability of the project;

7. Report on the progress of the approved project at least annually, or at intervals determined by the Committee;

8. (Where the research is publicly or privately funded) publish the results of the project is such a way to permit scrutiny and contribute to public knowledge; and

9. Ensure that the results of the research are made available to the participants.

Modifying your Ethical Clearance:
Requests for variations must be made via submission of a Request for Variation to Existing Clearance Form (http://www.research.qut.edu.au/ethics/forms/hum/var/var.jsp) to the Research Ethics Coordinator. Minor changes will be assessed on a case by case basis.

It generally takes 7-14 days to process and notify the Chief Investigator of the outcome of a request for a variation.

Major changes, depending upon the nature of your request, may require submission of a new application.

Audits:
All active ethical clearances are subject to random audit by the UHREC, which will include the review of the signed consent forms for participants, whether any modifications / variations to the project have been approved, and the data storage arrangements.

End of Document

Appendix 9 – Hanoi School of Public Health Human ethics approval certificate

MINISTRY OF HEALTH
HANOI SCHOOL OF PUBLIC HEALTH

No. 040/2013/YTCC-HD3
Subject: Ethical Approval

SOCIALIST REPUBLIC OF VIETNAM
Independence – Freedom - Happiness

Ha Noi, January 24, 2013

DECISION

On Ethical approval for research involving human subject participation

THE CHAIR OF THE ETHICAL REVIEW BOARD FOR BIOMEDICAL RESEARCH
HANOI SCHOOL OF PUBLIC HEALTH

- Based on Decision No. 201/QD-YTCC by the Dean of Hanoi School of Public Health on Establishment of The Institutional Ethical Review Board of Hanoi School of Public Health; 12 April 2012 ;
- Based on decision No. 202/QĐ-YTCC by the Dean of Hanoi School of Public Health on the Issuing Regulation of the Insitutional Ethical Review Board of Hanoi School of Public Health; 12 April 2012;
- After reviewing research ethics application No. **013-040/DD-YTCC**;
- And based on the memo dated **Janury 21, 2013.**

DECIDED

Article 1. Grant ethical approval for ethnographic study project:

- Project Title: **Access the cost- effective of intervention of promotion reproductive health of teenaging in CHILILAB, Vietnam.**
- Principal Investigator : **Nguyen Quynh Anh-** Dept.of Health Economic, Hanoi School of Public Health**;** PhD Student, Queensland University of Technology-Australia.
- Supervisor: Prof. Nicholas Graves- Queensland University of Technology- Australia.
- Research site: Chi Linh district, Hai Duong province, Vietnam.
- Baseline study time: from 24/01/2013 to 01/12/2013
- Project time: from 18/07/2011 to 18/07/2014
- Review process: expedited review

Article 2. This decision is effective from **24/01/2013**

Article 3. Principle Investigator should notify the Institutional Ethical Review Board of Hanoi School of Public Health (IRB of HSPH) immediately of any adverse effects arising from this study (e.g. unexpected adverse outcomes, unexpected community/subject risk factors or complaints, etc.). Active research projects are subject to random audit by the IRB of HSPH.

CHAIR OF INSTITUTIONAL ETHICAL REVIEW BOARD
(Signature and full name)
Do Mai Hoa

SECRETARY
(Signature and full name)
Nguyen Thi Minh Thanh

Appendix 10 – Questionnaire for data collection to estimate costs incurred by intervention participants and health care patients and families

Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT – Questionnaire for patients and family members –**

Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam

QUT Ethics Approval Number 1300000xxx

RESEARCH TEAM

Principal Researcher:	Quynh Anh Nguyen – PhD student – Queensland University of Technology (QUT)
Associate Researchers:	Professor Nicholas Graves and Professor Michael Dunne – QUT Assoc Professor Thanh Huong Nguyen – Hanoi School of Public Health – Vietnam

DESCRIPTION

This project is being undertaken as part of a PhD study for Quynh Anh Nguyen.

The purpose of this project is to examine the cost - effectiveness of the reproductive health interventions implemented in Chililab for adolescents in order to assist the intervention-provider team and local stakeholders to identify whether expansion of reproductive health education intervention to other areas should be considered.

You are invited to participate in this project because you are a patient or family member who is receiving health care treatment in Hai Duong hospital.

PARTICIPATION

This project involves your completion an attached questionnaire, which is an anonymous (non-identifiable) questionnaire. Your submission of this attached questionnaire will be considered as an indicator of your willingness to participate in this project and once you submitted your response; you will not be possible to withdraw from this project. If you agree to participate you do not have to complete any question(s) that you are uncomfortable answering.

It is estimated that the completion of this questionnaire will take approximately 15 - 20 minutes of your time. Questionnaire will include questions to inquire how much the patient and family member spend during treatment.

Your participation in this project is entirely voluntary. If you do not agree to participate, you can withdraw from the project without comment or penalty by not filling in the questionnaire. Your decision to participate or not participate will in no way impact upon your current or future relationship with your school, QUT, Hanoi School of Public Health.

EXPECTED BENEFITS

It is expected that this project will not directly benefit you. However, it may contribute to knowledge of cost-effective strategies for preventive, community-based reproductive health programs. Results from this research will assist the intervention-provider team and local stakeholders to identify which type of reproductive health education intervention is more cost-effective in order to target adolescent in Vietnam.
To recognise your contribution, should you choose to participate, the research team is offering participants a small gift values at AUD 10

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses. Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

CONSENT TO PARTICIPATE

The return of the completed questionnaire is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require any further information please contact one of the research team members below.

Quynh Anh Nguyen	Professor Nicholas Graves
School of Public Health and Social Work – QUT	Institute of Health and Biomedical Innovation – QUT
+61 478 708 228	+61 7 3138 6115
qa.nguyen@student.qut.edu.au	n.graves@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on +61 7 3138 5123 or email ethicscontact@qut.edu.au or Hanoi School of Public Health (138 Giang Vo, Ba Dinh, Hanoi) on +8442662336. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Queensland University of Technology Brisbane Australia	**QUESTIONNAIRE FOR DATA COLLECTION FROM PATIENTS AND FAMILY MEMBERS**
Research: Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam	

Questionnaire Number:

Patient registration Number:

Date of interview: ……………………………….(dd/mm/yy)

Interview name:

Patient Information *(to be filled in by Interviewer)*	
1. Gender	1. Male 2. Female
2. Age of patient	………………………………….(years old)
3. What is the highest level of education of the patient?	1. Not attended/illiterate 2. Completed primary school 3. Completed secondary school 4. Completed high school 5. Completed college 6. Other (specify)…………………………
4. Type of health care services receiving (circle)	1. Inpatient services 2. Outpatient services
5. Date of admission	………………………………….(dd/mm/yy)
6. Date of discharge	………………………………. (dd/mm/yy)

Insurance	
7. Do you have any kind of private or government health/medical insurance scheme? *If No, go to 10*	1. Yes 2. No
8. If YES: What type?	1. Compulsory insurance 2. Voluntary insurance 3. Insurance for the poor 4. Other (specify)…………………………
9. Have you received reimbursement for any costs related to the treatment?	1. Yes 2. No

Household Income	
10. How much do you estimate was the average income of your household per month (for all persons in the house, including patient; includes welfare payments, government assistance or other social support)	
a. Income patient:	......................................(VND)
b. Income rest of household	......................................(VND)
c. Welfare payments	......................................(VND)
d. Government assistance	......................................(VND)
e. Other:	......................................(VND)
TOTAL	......................................(VND)

Transportation costs – patient	
11. How many times do you have to travel between home to the hospital during this time of treatment?	.....................................(times)
12. Distance from home to the hospital?	.....................................(km)
13. What means of transportation do you take?	1. Bicycle 2. Motorbike 3. Car 4. Public transport *(go to next question)*
14. How much does it cost if you take transport? (both ways)	......................................(VND)

Transportation costs – family members	
15. How many times do all family members (who are care givers to patient during treatment) **have to travel between home to the hospital during this time of patient's treatment?**	.....................................(times)
16. Distance from home to the hospital?	.....................................(km)
17. What means of transportation do you take?	1. Bicycle 2. Motorbike 3. Car 4. Public transport *(go to next question)*
18. How much does it cost if you take transport? (both ways)	......................................(VND)

Accommodation costs – patient	
19. Do you have to pay for accommodation costs during this time of patient's treatment?	1. Yes (go to next question) 2. No (go to question 21)
20. How much do you have to pay for the accommodation cost?	.....................................(VND)

Accommodation costs – family members	
21. Do all family members (who are care givers to patient during treatment) **have to pay for accommodation costs during this time of patient's treatment?**	1. Yes (go to next question) 2. No (go to question 23)
22. How much do you have to pay for the accommodation cost?	.....................................(VND)

Meal costs – patient	
23. Do you have to pay for meal costs during this time of treatment?	1. Yes (go to next question) 2. No (go to question 26)
24. How many times do you have to pay for meal costs during this time of patient's treatment?	....................................(times)
25. How much do you have to pay on average for each meal?	.....................................(VND)

Meal costs – family members	
26. Do all family members (who are care givers to patient during treatment) **have to pay for meal costs during this time of treatment?**	1. Yes (go to next question) 2. No (completed the questionnaire)
27. How many times do you have to pay for meal costs during this time of patient's treatment?	....................................(times)
28. How much do you have to pay on average for each meal?	.....................................(VND)

Thank you for your cooperation!

Appendix 11 – Costing results

No.	Cost items	Live	Probabilistic	Point estimate (Mean)	Se (standard error)	Alpha	Beta	Min	Max	Type of distribution
C1A1	Intervention A - provider - total fixed cost	0	0	0	0			0	0	Deterministic
C1A1	Intervention A - provider - total fixed cost - VN rate	0.00	0	0	0			0	0	Deterministic
C1B1	Intervention B - provider -total fixed cost	36,432.00	53,626	692,208	529,751	2	405,422	1,038,312	1,730,520	Gamma(α,β),α,β>0
C1B1	Intervention B - provider -total fixed cost - VN rate	27,551.82	502,668	523,485	-44,514	138	3,785	261,742	436,237	Gamma(α,β),α,β>0
C1C1	Intervention C - provider -total fixed cost	52,511.25	1,060,020	997,714	763,556	2	584,354	1,496,571	2,494,284	Gamma(α,β),α,β>0
C1C1	Intervention C - provider -total fixed cost - VN rate	39,231.94	684,948	745,407	-63,385	138	5,390	372,703	621,172	Gamma(α,β),α,β>0
C1A2	Intervention A - provider - variable cost per participants	0.00	0	0	0			0	0	Deterministic
C1A2	Intervention A - provider - variable cost per participants - VN rate	0.00	0	0	0			0	0	Deterministic
C1B2	Intervention B - provider - variable cost per participant	5.22	110	99	13	61	2	74	124	Gamma(α,β),α,β>0

No.	Cost items	Live	Probabilistic	Point estimate (Mean)	Se (standard error)	Alpha	Beta	Min	Max	Type of distribution
C1B2	Intervention B - provider - variable cost per participant - VN rate	1.63	31	31	-3	138	0	15	26	Gamma(α,β),α,β>0
C1C2	Intervention C - provider - variable cost per participant	8.01	113	152	19	61	2	114	190	Gamma(α,β),α,β>0
C1C2	Intervention C - provider - variable cost per participant - VN rate	2.64	49	50	-4	138	0	25	42	Gamma(α,β),α,β>0
C2A	Intervention A - Participants per head	0.00	0	0	0			0	0	Deterministic
C2B	Intervention B - Participants per head	0.63	13	12	2	61	0	9	15	Gamma(α,β),α,β>0
C2C	Intervention C - Participants per head	1.27	25	24	2	106	0	17	29	Gamma(α,β),α,β>0
B1	Cost per Healthy case	0.00	0	0	0			0	0	Gamma(α,β),α,β>0
B2	Cost per Abortion case	54.88	1,212	1,043	133	61	17	782	1,303	Gamma(α,β),α,β>0
B3	Cost per Giving birth case	215.86	3,570	4,101	523	61	67	3,076	5,127	Gamma(α,β),α,β>0
B4	Cost per Post-abortion/delivery case	51.07	932	970	124	61	16	728	1,213	Gamma(α,β),α,β>0

No.	Cost items	Live	Probabilistic	Point estimate (Mean)	Se (standard error)	Alpha	Beta	Min	Max	Type of distribution
B5	Cost per HIV infection (Asymptomatic or untreated)	79.14	1,381	1,504	242	39	39	1,187	1,978	Gamma(α,β),α,β>0
B6	Cost per HIV infection (Treated)	295.79	4,303	5,620	919	37	150	4,452	7,421	Gamma(α,β),α,β>0
B7	Cost per Gonorrhea (Asymptomatic or untreated)	0.00	0	0	0			0	0	Gamma(α,β),α,β>0
B8	Cost per Chlamydia (Asymptomatic or untreated)	0.00	0	0	0			0	0	Gamma(α,β),α,β>0
B9.1	Cost per Gonorrhea (Treated)	22.77	423	433	55	61	7	325	541	Gamma(α,β),α,β>0
B9.2	Cost per Chlamydia (Treated)	19.34	446	368	47	61	6	276	459	Gamma(α,β),α,β>0
B10	Cost per PID treatment case	201.50	3,733	3,829	488	61	62	2,871	4,786	Gamma(α,β),α,β>0
B11	Cost per Deceased case	0.00	0	0	0			0	0	Gamma(α,β),α,β>0

Appendix 12 – EQ-5D instruments (Version for Vietnam and Australia)

Part 1: Original version for Australia

Health Questionnaire

English version for Australia

By placing a tick in one box in each group below, please indicate which statements best describe your own health state today.

Mobility

I have no problems in walking around	❑	PLEASE TICK
I have some problems in walking around	❑	ONE BOX
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	PLEASE TICK
I have some problems washing or dressing myself	❑	ONE BOX
I am unable to wash or dress myself	❑	

Usual Activities *(e.g. work, study, housework, family or leisure activities)*

I have no problems with performing my usual activities	❑	PLEASE TICK
I have some problems with performing my usual activities	❑	ONE BOX
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	PLEASE TICK
I have moderate pain or discomfort	❑	ONE BOX
I have extreme pain or discomfort	❑	

Anxiety/Depression

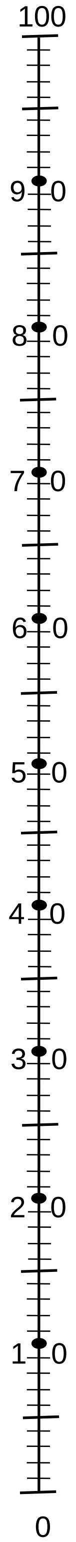
I am not anxious or depressed	❑	PLEASE TICK
I am moderately anxious or depressed	❑	ONE BOX
I am extremely anxious or depressed	❑	

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today.

Your own health state today

Best imaginable



Worst imaginable

Part 2: Consent form to collect data from students

Queensland University of Technology
Brisbane Australia

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Questionnaire for students –

Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam

QUT Ethics Approval Number 1300000xxx

RESEARCH TEAM

Principal Researcher:	Quynh Anh Nguyen – PhD student – Queensland University of Technology (QUT)
Associate Researchers:	Professor Nicholas Graves and Professor Michael Dunne – QUT Assoc Professor Thanh Huong Nguyen – Hanoi School of Public Health – Vietnam

DESCRIPTION

This project is being undertaken as part of a PhD study for Quynh Anh Nguyen.

The purpose of this project is to examine the cost - effectiveness of the reproductive health interventions implemented in Chililab for adolescents in order to assist the intervention-provider team and local stakeholders to identify whether expansion of reproductive health education intervention to other areas should be considered.

You are invited to participate in this project because you are a 11-grade student who is participating in the reproductive health education intervention for adolescents in Chi Linh district.

PARTICIPATION

This project involves your completion an attached questionnaire, which is an anonymous (non-identifiable) questionnaire. Your submission of this attached questionnaire will be considered as an indicator of your willingness to participate in this project and once you submitted your response; you will not be possible to withdraw from this project. If you agree to participate you do not have to complete any question(s) that you are uncomfortable answering.

It is estimated that the completion of this questionnaire will take approximately 15 - 20 minutes of your time. Questionnaire will include 7 parts; each part is about one health state. We wish to ask you to firstly give your valuations over five-item descriptive system, including mobility, personal care, usual activities, pain/discomfort and anxiety/depression for each health state and secondly rate these health states on a vertical, visual analogue scale where the endpoints are labelled “Best imaginable health state” and “Worst imaginable health state”.

Your participation in this project is entirely voluntary. If you do not agree to participate, you can withdraw from the project without comment or penalty by not filling in the questionnaire. Your decision to participate or not participate will in no way impact upon your current or future relationship with your school, QUT, Hanoi School of Public Health or your participation in the adolescent reproductive health education intervention in Chi Linh by Hanoi School of Public Health.

EXPECTED BENEFITS

It is expected that this project will not directly benefit you. However, it may contribute to knowledge of cost-effective strategies for preventive, community-based reproductive health programs. Results from this research will assist the intervention-provider team and local stakeholders to identify which type of reproductive health education intervention is more cost-effective in order to target adolescent in Vietnam.
To recognise your contribution, should you choose to participate, the research team is offering participants a school-kit values at AUD 10

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses. Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

CONSENT TO PARTICIPATE

The return of the completed questionnaire is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require any further information please contact one of the research team members below.

Quynh Anh Nguyen	Professor Nicholas Graves
School of Public Health and Social Work – QUT	Institute of Health and Biomedical Innovation – QUT
+61 478 708 228	+61 7 3138 6115
qa.nguyen@student.qut.edu.au	n.graves@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on +61 7 3138 5123 or email ethicscontact@qut.edu.au or Hanoi School of Public Health (138 Giang Vo, Ba Dinh, Hanoi) on +8442662336. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

***Thank you for helping with this research project. Please keep this sheet for your information*.**

Part 3: Refined version for data collection in Vietnam

Queensland University of Technology Brisbane Australia	QUESTIONNAIRE FOR EVALUATING HEALTH RELATED QUALITY OF LIFE OF DIFFERENT HEALTH STATES FROM ADOLESCENTS' POINT OF VIEWS

***Research*: Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam**

Question 1: By placing a tick in one box in each group below, please indicate which statements best describe **your own health state today**.

Mobility

I have no problems in walking around	❑	PLEASE TICK
I have some problems in walking around	❑	ONE BOX
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	PLEASE TICK
I have some problems washing or dressing myself	❑	ONE BOX
I am unable to wash or dress myself	❑	

Usual Activities *(e.g. work, study, housework, family or leisure activities)*

I have no problems with performing my usual activities	❑	PLEASE TICK
I have some problems with performing my usual activities	❑	ONE BOX
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	PLEASE TICK
I have moderate pain or discomfort	❑	ONE BOX
I have extreme pain or discomfort	❑	

Anxiety/Depression

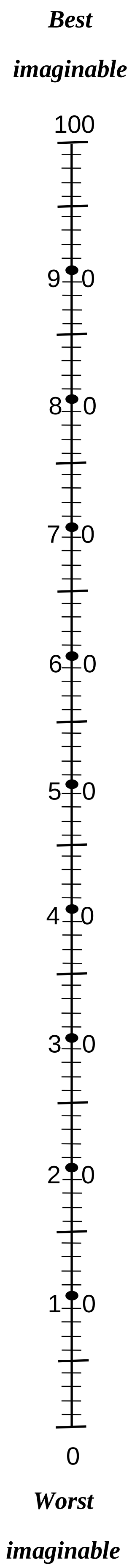
I am not anxious or depressed	❑	PLEASE TICK
I am moderately anxious or depressed	❑	ONE BOX
I am extremely anxious or depressed	❑	

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today.

Your own

health state



Question 2: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a "healthy state".

By placing a tick in one box in each group below, please indicate which statements best describe Z's health state.

Mobility

I have no problems in walking around	❑	PLEASE TICK
I have some problems in walking around	❑	ONE BOX
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	PLEASE TICK
I have some problems washing or dressing myself	❑	ONE BOX
I am unable to wash or dress myself	❑	

Usual Activities *(e.g. work, study, housework, family or leisure activities)*

I have no problems with performing my usual activities	❑	PLEASE TICK
I have some problems with performing my usual activities	❑	ONE BOX
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	PLEASE TICK
I have moderate pain or discomfort	❑	ONE BOX
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	PLEASE TICK
I am moderately anxious or depressed	❑	ONE BOX
I am extremely anxious or depressed	❑	

<u>Question 3</u>: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a “unwanted pregnant state”.

By placing a tick <u>in one box in each group</u> below, please indicate which statements best describe Z’s health state.

Mobility

I have no problems in walking around	❑	<u>PLEASE TICK</u>
I have some problems in walking around	❑	<u>ONE BOX</u>
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	<u>PLEASE TICK</u>
I have some problems washing or dressing myself	❑	<u>ONE BOX</u>
I am unable to wash or dress myself	❑	

Usual Activities *(e.g. work, study, housework, family or leisure activities)*

I have no problems with performing my usual activities	❑	<u>PLEASE TICK</u>
I have some problems with performing my usual activities	❑	<u>ONE BOX</u>
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	<u>PLEASE TICK</u>
I have moderate pain or discomfort	❑	<u>ONE BOX</u>
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	<u>PLEASE TICK</u>
I am moderately anxious or depressed	❑	<u>ONE BOX</u>
I am extremely anxious or depressed	❑	

Question 4: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a “giving birth state”. By placing a tick in one box in each group below, please indicate which statements best describe Z’s health state.

Mobility

I have no problems in walking around	❑	PLEASE TICK
I have some problems in walking around	❑	ONE BOX
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	PLEASE TICK
I have some problems washing or dressing myself	❑	ONE BOX
I am unable to wash or dress myself	❑	

Usual Activities

(e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities	❑	PLEASE TICK
I have some problems with performing my usual activities	❑	ONE BOX
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	PLEASE TICK
I have moderate pain or discomfort	❑	ONE BOX
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	PLEASE TICK
I am moderately anxious or depressed	❑	ONE BOX
I am extremely anxious or depressed	❑	

<u>Question 5</u>: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a "post abortion or post-giving birth state".

By placing a tick <u>in one box in each group</u> below, please indicate which statements best describe Z's health state.

Mobility

I have no problems in walking around	❑	<u>PLEASE TICK</u>
I have some problems in walking around	❑	<u>ONE BOX</u>
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	<u>PLEASE TICK</u>
I have some problems washing or dressing myself	❑	<u>ONE BOX</u>
I am unable to wash or dress myself	❑	

Usual Activities

(e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities	❑	<u>PLEASE TICK</u>
I have some problems with performing my usual activities	❑	<u>ONE BOX</u>
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	<u>PLEASE TICK</u>
I have moderate pain or discomfort	❑	<u>ONE BOX</u>
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	<u>PLEASE TICK</u>
I am moderately anxious or depressed	❑	<u>ONE BOX</u>
I am extremely anxious or depressed	❑	

<u>Question 6</u>: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a "HIV infected (asymptomatic or untreated) state".

By placing a tick <u>in one box in each group</u> below, please indicate which statements best describe Z's health state.

Mobility

I have no problems in walking around	❑	<u>PLEASE TICK</u>
I have some problems in walking around	❑	<u>ONE BOX</u>
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	<u>PLEASE TICK</u>
I have some problems washing or dressing myself	❑	<u>ONE BOX</u>
I am unable to wash or dress myself	❑	

Usual Activities

(e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities	❑	<u>PLEASE TICK</u>
I have some problems with performing my usual activities	❑	<u>ONE BOX</u>
I am unable to perform my usual activities	❑	

Pain/Discomfort

I have no pain or discomfort	❑	<u>PLEASE TICK</u>
I have moderate pain or discomfort	❑	<u>ONE BOX</u>
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	<u>PLEASE TICK</u>
I am moderately anxious or depressed	❑	<u>ONE BOX</u>
I am extremely anxious or depressed	❑	

Question 7: Please imagine of an adolescent, name Z, 13 – 18 years of age, on a "HIV infected (symptomatic and treated) state".

By placing a tick in one box in each group below, please indicate which statements best describe Z's health state.

Mobility

I have no problems in walking around	❑	PLEASE TICK
I have some problems in walking around	❑	ONE BOX
I am confined to bed	❑	

Personal Care

I have no problems with personal care	❑	PLEASE TICK
I have some problems washing or dressing myself	❑	ONE BOX
I am unable to wash or dress myself	❑	

Usual Activities

(e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities	❑	PLEASE TICK
I have some problems with performing my usual activities	❑	ONE BOX
I am unable to perform my usual activities	❑	

Pain/Discomfort

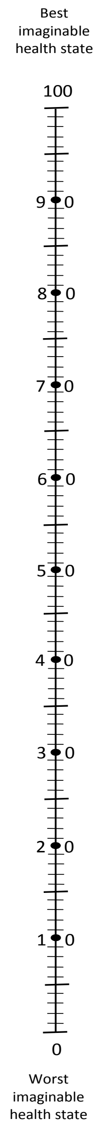
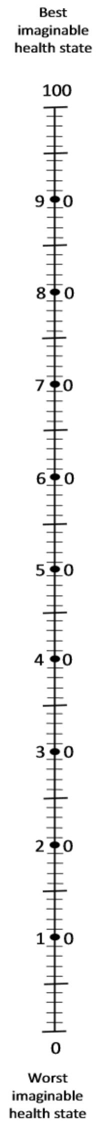
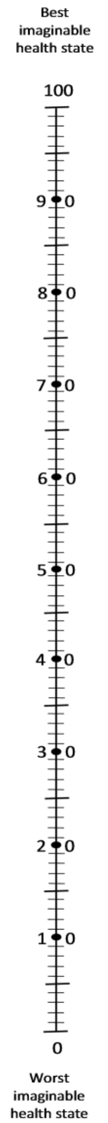
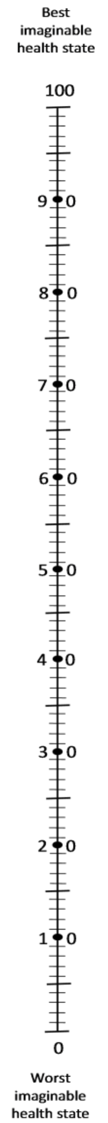
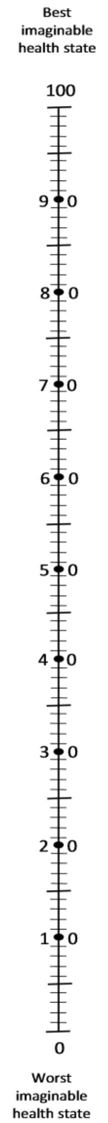
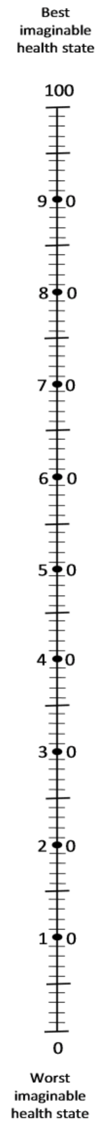
I have no pain or discomfort	❑	PLEASE TICK
I have moderate pain or discomfort	❑	ONE BOX
I have extreme pain or discomfort	❑	

Anxiety/Depression

I am not anxious or depressed	❑	PLEASE TICK
I am moderately anxious or depressed	❑	ONE BOX
I am extremely anxious or depressed	❑	

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad each health state mentioned above is, in your opinion. Please do these by putting a tick on whichever point on the scale indicates how good or bad Z's health state is.

Question 2: healthy	**Question 3**: Unwanted pregnant	**Question 4**: Giving birth	**Question 5**: Post – abortion/ post-delivery	**Question 6**: HIV infected (asymptomatic or untreated)	**Question 7**: HIV infected (symptomatic and treated)
					

Appendix 13 – Questionnaire for elicitation of expert opinions

Part 1: Consent form to collect data from experts

Queensland University of Technology
Brisbane Australia

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Questionnaire for health care experts –

Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam

QUT Ethics Approval Number 1300000xxx

RESEARCH TEAM

Principal Researcher:	Quynh Anh Nguyen – PhD student – Queensland University of Technology (QUT)
Associate Researchers:	Professor Nicholas Graves and Professor Michael Dunne – QUT Assoc Professor Thanh Huong Nguyen – Hanoi School of Public Health – Vietnam

DESCRIPTION

This project is being undertaken as part of a PhD study for Quynh Anh Nguyen.

The purpose of this project is to examine the cost - effectiveness of the reproductive health interventions implemented in Chililab for adolescents in order to assist the intervention-provider team and local stakeholders to identify whether expansion of reproductive health education intervention to other areas should be considered.

You are invited to participate in this project because you are a health care expert in Vietnam, who has background and experience in both health promotion (i.e. health education interventions) and reproductive health among adolescents.

PARTICIPATION

This project involves your completion an attached questionnaire, which is an anonymous (non-identifiable) questionnaire. Your submission of this attached questionnaire will be considered as an indicator of your willingness to participate in this project and once you submitted your response; you will not be possible to withdraw from this project. If you agree to participate you do not have to complete any question(s) that you are uncomfortable answering.

It is estimated that the completion of this questionnaire will take approximately 30–45 minutes of your time. Questionnaire will include a "Background information" part, which will provide you more information of the adolescent reproductive health education intervention, "a hypothetical example", which will help you understand the principle of the valuation technique and a total of 6 structured questions. Once you complete the questionnaire, please send it back via mail to Quynh Anh Nguyen (Health economics department, Hanoi School of Public Health, 138 Giang Vo, Ba Dinh, Hanoi) or via email to qa.nguyen@student.qut.edu.au with pdf attachment.

Your participation in this project is entirely voluntary. If you do agree to participate, you can withdraw from the project without comment or penalty. Your decision to participate, or not participate, will in no way impact upon your current or future relationship with QUT or the Hanoi School of Public Health.

EXPECTED BENEFITS

It is expected that this project will not directly benefit you. However, it may contribute to knowledge of cost-effective strategies for preventive, community-based reproductive health programs. Results from this research will assist the intervention-provider team and local stakeholders to identify which type of reproductive health education intervention is more cost-effective in order to target adolescent in

Vietnam.

To recognise your contribution should you choose to participate, the research team is offering participants a shopping voucher values at AUD 50

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses. Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

CONSENT TO PARTICIPATE

The return of the completed questionnaire is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require any further information please contact one of the research team members below.

Quynh Anh Nguyen	Professor Nicholas Graves
School of Public Health and Social Work – QUT	Institute of Health and Biomedical Innovation – QUT
+61 478 708 228	+61 7 3138 6115
qa.nguyen@student.qut.edu.au	n.graves@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on +61 7 3138 5123 or email ethicscontact@qut.edu.au or Hanoi School of Public Health, 138 Giang Vo, Ba Dinh, Hanoi. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Part 2: Questionnaire for expert elicitation

Queensland University of Technology Brisbane Australia	QUESTIONNAIRE FOR ELICITATION OF EXPERT OPINIONS

Research: Economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam

Adolescents and youths in Vietnam aged between 11 and 18 make up a significant proportion of the country's population. The ability of young people to contribute to a nation's productivity and prosperity depends to a great extent on how well they can avoid health risks and chronic diseases, including those associated with sexual and reproductive health. Therefore, reproductive health care and prevention programs for young people are prioritized at all levels in Vietnam.

Hanoi School of Public Health with support from the Ford Foundation is carrying out a reproductive health education intervention at Chililab DESS (a Demographic and Epidemiologic Surveillance System located in the Chi Linh district at Hai Duong province, in northern Vietnam). At the end of the intervention phase, an economic evaluation will need to be undertaken. However, the effectiveness of the reproductive health education intervention is unknown and cannot reliably estimated from limited available literature in Vietnam, expert opinion will be consulted in order to estimate these effectiveness parameters.

You are invited to answer this questionnaire, which will be used within the economic evaluation of different levels of adolescent reproductive health education intervention in Chi Linh, Vietnam. This questionnaire is an anonymous (non-identifiable) questionnaire. Questionnaire will include a "Background information" part, which will provide you more information of the adolescent reproductive health education intervention, "a hypothetical example", which will help you understand the principle of the valuation technique and a total of 6 structured questions.

Background information:

Objectives of the intervention

The overall goal of this intervention program is to foster a supportive environment to address the problems faced by adolescents and youths aged 11-18 by making existing health services more accessible and providing reproductive health and health risk behaviour education to enable them to gain mastery over these behaviours..

Intervention study design

The intervention will be based on the Chililab DESS in seven communes or towns of Chi Linh district - with ongoing activities to collect data on the population and community health on a quarterly basis and the longitudinal adolescent health study with three modules as mentioned above. In this intervention, seven communes or towns of Chililab DESS are divided into three sites (called A, B and C).

- Site A (one town – Pha Lai and two communes – Le Loi and Hoang Tien): will be the control site and will not receive any interventions.
- Site B (one town – Ben Tam and one commune – An Lac): will receive school-based components (**without** emphasis on transforming gender relations to promote gender equity) and health facility interventions
- Site C (one town – Sao Do and one commune – Van An): will receive school-based components, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Target audience and sample estimation

All secondary and high school students, aged 11-18 (in 2011, around 13,000) and their parents will be included as primary and secondary target groups, respectively.

Main activities of the intervention

- Training health care providers (about 25), school teachers (about 40) and key school students (about 100) in order to be able to provide appropriate information, activities and services to adolescents.
- Establishing and implementing counselling and friendly corners in all participating schools.
- Developing and implementing reproductive health curriculum in all participating schools for all students in an appropriate manner.
- Upgrading and providing youth friendly services related to reproductive health problems all four health facilities.
- Organising various community-based activities such as individual and group discussions, sport events…
- Delivering materials and encouraging both adolescents and their parents to read these materials and discuss about reproductive health.

What we want to do:

We wish to ask you to think about plausible improvement (e.g differences) on some measures of reproductive health among adolescents in site A (no intervention) compared to those in site B and site C (interventions with different levels). The expected improvement would be expressed via six parameters: (1) rate of having premarital sexual intercourses among adolescents, (2) change in the incidence of having premarital sexual intercourses, (3) change in the proportion of using condoms among sexually active adolescents, (4) change in the proportion of using condom properly among sexually active adolescents, (5) change in the average number of intercourses for the last 3 months among sexually active adolescents and (6) change in the average number of partners per sexually active adolescent within the last 3 months.

We would like to stress that we are asking about the average differences that you would expect to observe over thousands of adolescents, who are participants in the reproductive health education intervention, not the random differences that you might expect to observe between individuals. Naturally you are not sure what the real difference between three different scenarios, no intervention, intervention at site B and intervention at site C (if any). Nonetheless you may feel that some differences are more plausible than others. We therefore ask you to enter your weight of belief for each of the possible differences shown in the following table. On a scale of 0 (impossible) to 100 (certainty), the more strongly you believe the plausibility of a particular difference, the greater should be your weight for that difference. Your weight should sum to 100.

If anything is not clear, or you have any comments then please contact Quynh Anh Nguyen on (0084) 912 118311 or by email on qa.nguyen@student.qut.edu.au

Interviewer’s institution:...

<u>Question 1</u>: What is your belief of **the incidences** (%) **of becoming sexually active adolescents among adolescents** (13 - 18 years old) **within the <u>last 3 months</u>**?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

A hypothetical example is included in order to help you understand the principle of this technique.

Parameter	**0-1%**	**1.1-2%**	**2.1-3%**	**3.1-4%**	**4.1-5%**	**5.1-6%**	**6.1-7%**	**>7%**	**Other.....**	**Total**
Hypothetical example	0	0	20	20	20	20	20	0	0	100
Male adolescents – site A (%)										
Male adolescents – site B (%)										
Male adolescents – site C (%)										
Female adolescents – site A (%)										
Female adolescents – site B (%)										
Female adolescents – site C (%)										

Please check your weights sum to 100

Question 2: What is your belief of **the rate (%) of having premarital sexual intercourses among adolescents** (13 - 18 years old) at 6/2013?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Parameter	**0-5%**	**>5-10%**	**>10-15%**	**>15-20%**	**>20-25%**	**>25-30%**	**>30-35%**	**>35-40%**	**>40%**	**Other.....**	**Total**
Male adolescents – site A (%)											
Male adolescents – site B (%)											
Male adolescents – site C (%)											
Female adolescents – site A (%)											
Female adolescents – site B (%)											
Female adolescents – site C (%)											

Please check your weights sum to 100

<u>Question 3</u>: What is your belief of the **rate** (%) **of using condoms among sexually active adolescents** (13 - 18 years old) in their previous sexual intercourse?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Parameter	**0-10%**	**>10-20%**	**>20-30%**	**>30-40%**	**>40 - 50%**	**>50 - 60%**	**>60-70%**	**>70-80%**	**>80-90%**	**>90%**	**Total**
Male adolescents – site A (%)											
Male adolescents – site B (%)											
Male adolescents – site C (%)											
Female adolescents – site A (%)											
Female adolescents – site B (%)											
Female adolescents – site C (%)											

Please check your weights sum to 100

Question 4: What is your belief of the **rate of using condom properly/correctly among sexually active adolescents** (%) at their previous sexual intercourse?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Parameter	**0-10%**	**>10-20%**	**>20-30%**	**>30-35%**	**>35-40%**	**>45-50%**	**>50-55%**	**>55-60%**	**>60-70%**	**>70-80%**	**>80-90%**	**>90%**	**Total**
Male adolescents – site A (%)													
Male adolescents – site B (%)													
Male adolescents – site C (%)													
Female adolescents – site A (%)													
Female adolescents – site B (%)													
Female adolescents – site C (%)													

Please check your weights sum to 100

Question 5: What is your belief of the **average number of sexual intercourses within <u>the last 3 months</u> among sexually active adolescents**?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Parameter	**0-3 times**	**4-6 times**	**7-9 times**	**10-12 times**	**13-15 times**	**16-18 times**	**19-21 times**	**22-24 times**	**>24 times**	**Other...**	**Total**
Male adolescents – site A											
Male adolescents – site B											
Male adolescents – site C											
Female adolescents – site A											
Female adolescents – site B											
Female adolescents – site C											

Please check your weights sum to 100

<u>Question 6</u>: What is your belief of the **average number of partners per sexually active adolescent within the <u>last 3 months</u>**?

- Site A: serves as the control site as it is not receiving any interventions.
- Site B: receiving school-based (**without** emphasizing transforming gender relations to promote gender equity) and health facility interventions
- Site C: receiving school-based, community interventions (**with** emphasis on transforming gender relations to promote gender equity) and health facility interventions.

Parameter	**1 partner**	**2 partners**	**3 partners**	**>3 partners**	**Other.....**	**Total**
Hypothetical example	40	30	20	10		100
Male adolescents – site A						
Male adolescents – site B						
Male adolescents – site C						
Female adolescents – site A						
Female adolescents – site B						
Female adolescents – site C						

Please check your weights sum to 100

Thank you very much for your help

Appendix 14 – Data sources for health state costs calculation

1. Cost per healthy case (during 3 months period) Unit: 1,000

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
			1	0	0	0	0	
B	**Indirect health care cost**							
			0	2	0	0	0	
C	**Direct non-health care cost**							
			1	0	0	0	0	
D	**Indirect non-health care cost**							
			1	0	0	0	0	
	Total per case				**0**	**0**	**0**	

2. Cost per abortion case (during 3 months period) Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Fee for service - Abortion from 13 - 22 weeks with drugs	abortion case	1	430	430	323	538	TTLT - 04 - BYTBTC
B	**Indirect health care cost**							
	1 inpatient day care	IP day	1	35	35	26	43	

C	**Direct non-health care cost**							
	Accommodation, transportation, meal (patient + 1 care giver)	day	2	198	395	297	494	
D	**Indirect non-health care cost**							
	Productivity lost	day	2	91	183	137	228	
	Total per case				**1,043**	**782**	**1,303**	

3. Cost per giving birth case (over 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Fee for service - giving birth	Giving birth case	1	1,038	1,038	778	1,297	TTLT - 04 - BYTBTC
B	**Indirect health care cost**							
	Inpatient day care in the hospital	IP day	5	35	173	130	216	
C	**Direct non-health care cost**							
	Accommodation, transportation, meal (patient + 1 care giver)	day	10	198	1,977	1,483	2,471	
D	**Indirect non-health care cost**							
	Productivity lost	day	10	91	914	685	1,142	
	Total per case				**4,101**	**3,076**	**5,127**	

4. Cost per Post-abortion/giving birth case (over 3 months period) Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Fee for service - counselling	Counselling case	3	200	600	450	750	TTLT - 04 - BYTBTC
B	**Indirect health care cost**							
	Outpatient	times	3	2	7	5	9	
C	**Direct non-health care cost**							
	Transportation for patient and 1 care giver	times	6	15	89	67	111	
D	**Indirect non-health care cost**							
	Productivity lost	day	3	91	274	206	343	
	Total per case				**970**	**728**	**1,213**	

5.1. Cost per treatment for HIV (Asymptomatic or untreated) (during 3 months period) Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
		per case	0	2,388	0	0	0	Tran Tuan Cuong's thesis, table 5

B	**Indirect health care cost**							
			0		0	0	0	
C	**Direct non-health care cost**							
			0		0	0	0	
D	**Indirect non-health care cost**							
			0		0	0	0	
	ARV drugs							ref 147 va WHO 2005
	Total per case (3months treatment cost per case)				**0**	**0**	**0**	

5.2. Cost per side effect or opportunity diseases treatment for People with HIV (Asymptomatic or untreated) (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
		per case	1	175	175	131	219	Tran Tuan Cuong's thesis, figure 8
B	**Indirect health care cost**							
		inpatient day	10	35	346	259	432	
C	**Direct non-health care cost**							
	Transportation for patient and 1 care giver	times	10	15	148	111	185	
D	**Indirect non-health care cost**							

	Productivity lost	day	10	91	914	685	1,142	
	Total per case (3 months treatment cost per case)				**1,583**	**1,187**	**1,978**	

Difference of need in treatment for opportunity diseases for PLWH

Condition	Unit	Probability	Source
		Mean	
HIV (ARV treatment) + good adherence		80.0%	
HIV (unknown)		95.0%	

6.1 Cost per ARV treatment for HIV (treated) (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Cost from health care providers' perspective	per case	1	2,388	2,388	1,791	2,984	Tran Tuan Cuong's thesis, table 5
B	**Indirect health care cost**							
	Times of having examination and receive medicine - outpatient	times	11	2	26	19	32	Tran Tuan Cuong's thesis, table 4
C	**Direct non-health care cost**							

		per case	1	979	979	734	1,223	Tran Tuan Cuong's thesis, table 8
D	**Indirect non-health care cost**							
	Productivity lost	days per 3 months	11	91	962	722	1,203	
	ARV drugs							ref 147 va WHO 2005
	Total per case (3 months treatment cost per case)				**4,354**	**3,265**	**5,442**	

6.2. Cost per side effect or opportunity diseases treatment for People with HIV (treated) (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
		per case	1	175	175	131	219	Tran Tuan Cuong's thesis, figure 8
B	**Indirect health care cost**							
		IP day	10	35	346	259	432	
C	**Direct non-health care cost**							
	Transportation for patient and 1 care giver	times	10	15	148	111	185	
D	**Indirect non-health care cost**							
	Productivity lost	per case	10	91	914	685	1,142	
	Total per case (3 months treatment cost per case)				**1,583**	**1,187**	**1,978**	

Difference of need in treatment for opportunity diseases for PLWH

Condition	Unit	Probability	Source
		Mean	
HIV (known) + good adherence		80.0%	
HIV (unknown)		95.0%	

7. Cost per Gonorrhea (Asymptomatic or Untreated) treatment case (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
		Case	1	0	0	0	0	
B	**Indirect health care cost**							
		Case	1	0	0	0	0	
C	**Direct non-health care cost**							
		Day	1	0	0	0	0	
D	**Indirect non-health care cost**							
		Day	1	0	0	0	0	
	Total per case (life-time treatment cost per case)				**0**	**0**	**0**	

8. Cost per Chlamydia (Asymptomatic or Untreated) treatment case (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
		Case	1	0	0	0	0	
B	**Indirect health care cost**							
		Case	1	0	0	0	0	
C	**Direct non-health care cost**							
		Day	1	0	0	0	0	
D	**Indirect non-health care cost**							
		Day	1	0	0	0	0	
	Total per case				**0**	**0**	**0**	

9.1. Cost per Gonorrhea treatment case (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Diagnose test	test	2	57.00	114	86	143	Item 379 - TTLT 04 BYTBTC

	Spectinomycin 40mg/kg, injection, 1 dose only	dose	1	68.00	68	51	85	Item 1377 - imported drugs cost
	Doxycycline, 2 times per day, 7 days	dose	14	2.22	31	23	39	Item 1306 - imported drugs cost
B	**Indirect health care cost**							
	OP treatment (1 test and 1 diagnos and 1 injection)	OP services	3	2.44	7	5	9	
C	**Direct non-health care cost**							
	Transportation (1 patient and 1 care giver)	day	2	14.80	30	22	37	
D	**Indirect non-health care cost**							
	Productivity lost	day	2	91.38	183	137	228	
	Total per case				**433**	**325**	**541**	

9.2. Cost per Chlamydia treatment case (during 3 months period)

Unit: 1,000VND

No	Cost items	Unit	Quantity	Unit cost	Total cost			Sources
			Mean	Mean	Mean	Min	Max	
A	**Direct health care cost**							
	Diagnose test	test	2	57	114	86	143	Item 379 - TTLT 04 BYTBTC
	Azithromycin, only 1 dose	dose	1	3	3	2	3	Item 142 - imported drugs cost

	Doxycycline, 2 times per day, 7 days	dose	14	2	31	23	39	Item 1306 - imported drugs cost
B	**Indirect health care cost**							
	OP treatment (1 test and 1 diagnos and 1 injection)	OP services	3	2.44	7	5	9	
C	**Direct non-health care cost**							
	Transportation (1 patient and 1 care giver)	day	2	14.80	30	22	37	
D	**Indirect non-health care cost**							
	Productivity lost	day	2	91.38	183	137	228	
	Total per case				**368**	**276**	**459**	

10. Cost per PID treatment case (during 3 months period) Unit: 1,000VND

No	**Cost items**	**Unit**	**Quantity**	**Unit cost**	**Total cost**			**Sources**
			Mean	**Mean**	**Mean**	**Min**	**Max**	
A	**Direct health care cost**							
	Diagnose test	test	2	57.00	114	86	143	Item 379 - TTLT 04 BYTBTC
	Ceftriaxon 250mg, injection, 1 dose only	dose	1	16.50	17	12	21	Item 1356 - imported drugs cost
	Metronidazol 400mg x 2 times per day x 14 days	dose	28	20.98	587	441	734	Item 214 - imported drugs cost
	Doxycyclin 100mg x 2 times/day x 14 days	dose	28	2.22	62	47	78	Item 1306 - imported drugs cost

B	**Indirect health care cost**							
	OP treatment (1 test and 1 diagnos and 29 injections)	OP services	31	2.44	76	57	95	
C	**Direct non-health care cost**							
	Transportation (1 patient and 1 care giver)	day	28	14.80	414	311	518	
D	**Indirect non-health care cost**							
	Productivity lost	day	28	91.38	2,559	1,919	3,198	
	Total per case				**3,829**	**2,871**	**4,786**	

2.11. Cost per Dead case (during 3 months period)

Unit: 1,000VND

No	**Cost items**	**Unit**	**Quantity**	**Unit cost**	**Total cost**			**Sources**
			Mean	**Mean**	**Mean**	**Min**	**Max**	
A	**Direct health care cost**							
			1	0	0	0	0	TTLT - 04 - BYTBTC
B	**Indirect health care cost**							
					0	0	0	
C	**Direct non-health care cost**							
					0	0	0	
D	**Indirect non-health care cost**							
					0	0	0	
	Total per case				**0**	**0**	**0**	